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Unemployment Soars to 8.9%

The [illegible] benefits start to flow

Increase

And Gasoline

Slump's End Is Near

Prices for Farm Products Decline 3.1% in December

U.S. Payments Surplus Widened [illegible] Quarter

Bosses Worry About the Recession, But Inflation Concerns Have Eased

Many Analysts See 1st Half Drop in Prime Fee But Expect Little Easing for Long-Term Rates

Inflation Put At 3-Year Low In November

Reagan Hopes for More Jobs in Spring

Personal Income Rose Only 0.6% For November

[illegible] Industries' Pay Boosts Were More Than Offset by [illegible] Factory Payrolls

Salomon's Kaufman Offers Gloomy View Of '82 Interest Rates

• • •

[illegible] Levels 'Probably' Will Near '81 Highs by [illegible] End,' Influential Forecaster Says

WINTER 1982 VOLUME 17, NUMBER 3

survey of business

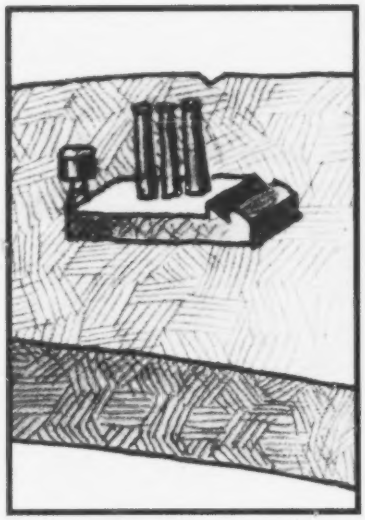
THE UNIVERSITY OF TENNESSEE, KNOXVILLE

5

Looking Ahead: 1982 Economic Outlook Survey
Patricia D. Postma
Research Associate, Center for Business and Economic Research

21

Outlook for Specific Industries
Richard A. Hofler, Research Assistant Professor, CBER
John W. Mayo, Research Assistant Professor, CBER
Patricia D. Postma, Research Associate, CBER
Niles C. Schoening, Research Associate, CBER



14

Outlook for Tennessee and the Nation
William F. Fox
Research Associate Professor, CBER, and Associate Professor of Finance, UT

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An Introduction

This issue of the **Survey** contains the thirteenth annual analysis of the outlook for the Tennessee economy. The first article presents the responses of the 1982 Economic Outlook Business Panel, composed of 158 leading businessmen and women from all sectors of the state's economy. (This year's panelists are listed below and on the next page).

The second and third articles of the issue provide both a near-term and longer-run (to 1990) economic forecast for Tennessee, with selected U.S. forecast variables for comparison purposes. The specific state economic forecast referenced in "Outlook for Tennessee and the Nation" and "Outlook for Specific Industries" was developed by the Center for Business and Economic Research staff, utilizing the Annual Tennessee Econometric Model, a tool of substantial assistance in the ongoing regional economic analysis mission of the College of Business Administration at The University of Tennessee, Knoxville.

Since the Outlook issue of the **Survey** is prepared for the benefit of all our readers, comments regarding the content and presentation are welcomed.

David A. Hake, Director
Center for Business and Economic Research

PANELISTS FOR THE 1982 SURVEY OF BUSINESS ATTITUDES

Norbert J. Ackerman, Jr., President, Technology for Energy Corporation, Concord
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(Continued on next page)

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Tom Yount, Senior Vice-President, EG & G Instruments and Testing Service Groups, Oak Ridge

Allen Zang, President, Nashville Bridge Company, Nashville

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* These panelists have served five or more years since the first Economic Outlook edition.

† These panelists have served ten or more years since the first Economic Outlook edition.

Looking Ahead: 1982 Economic Outlook

Patricia D. Postma

By November 1981, when respondents to the 13th annual **Survey of Business** questionnaire considered Tennessee's outlook for 1982, a variety of new federal initiatives had brought deregulation in several industries, tax cuts, and sharp decreases in federal programs, especially those providing money to state and local governments. Inflation appeared to be receding, but nation and state were once again in recession, while federal budget deficits and high interest rates were proving to be intractable.

This 1982 panel, 158 businessmen and women from West, Middle, and East Tennessee, is the largest in the survey's 13-year history. Their views about the future of the economy are summarized in the following comments.

• PANEL MEMBERS HAVE MIXED FEELINGS ON THE OUTLOOK FOR 1982.

Although about 40 percent of the panelists think both the U.S. and Tennessee will fare slightly better in 1982, equal numbers of respondents believe 1982 will be slightly to substantially worse.

The Tennessee economy will improve more slowly than the national economy because auto sales will still be slow, thus hurting parts manufacturing in Tennessee; housing will not pick up soon enough to help furniture manufacturers; and TVA is apt to close down still more of its nuclear plant construction sites.

West Tennessee publisher

I believe the (state) economy will be better than the economy nationally. We will begin to realize some of the fruits of a very successful state industrial development effort. Expo '82 in Knoxville and an expanded Opryland in Nashville and the fallout from both of these will have a favorable impact on the economy as a whole.

East Tennessee manufacturer

• PANEL MEMBERS BELIEVE THAT HIGH INTEREST RATES CONTINUE TO BE THE MOST SERIOUS PROBLEM FOR 1982.

Seventy percent of the panelists expect rates to be lower in 1982, but levels will still be high enough to constrain economic growth.

High interest rates force a greater degree of conservatism in business expansion decisions (such as) short-term strategic decisions which damage long-term planning focus.

East Tennessee manufacturer

• MOST PANEL MEMBERS SUPPORT PRESIDENT REAGAN'S ECONOMIC PROGRAM, ACKNOWLEDGING THAT DIFFICULT TIMES ARE PROBABLY REQUIRED FOR SUCCESS.

Reagan's cure can work substantially, if not completely. But it is a slow cure and will accomplish little unless it is applied with an even, steady hand for at least three or four years. The chances of the United States being willing to chew such a bitter pill for so long are not great.

Middle Tennessee development official

• PANEL MEMBERS HAVE MIXED FEELINGS ABOUT TENNESSEE'S FISCAL NEEDS.

Those who think that savings can be made through better program management are well represented, but so are those who think changes are needed in the state tax structure.

. . . Our major weakness is our tax base, with entirely too much dependency on a regressive sales tax. We will face a government revenue crunch in 1982, paralleling the nation's, due to federal cuts in funds. We have serious problems in our correction institutions and some problems in our higher education funding.

West Tennessee banker

I believe that most services can be maintained at the present level by introducing the word 'efficiency' to the administrators of services .... More money does not equate to more services.

East Tennessee construction executive

The Outlook for 1982

Clearly, our 1982 panel members are less optimistic about the year ahead than they were a year ago. More than 70 percent of last year's panel expected 1981 to bring an upswing in the economy. For 1982, only 40 percent expect an upturn, while 37 percent expect a continuation of the 1981 year-end decline. Figure 1 illustrates the panel's contrasting expectations for the two years.

Panelists agree that some aspects of the Tennessee economy will worsen in 1982. These could be characterized as aspects which are symptomatic of recessions: for example, consumer demand and plant utilization are expected to decline, and unemployment is expected to be higher. Unemployment is perceived as the worst problem facing Tennessee, with the exception of the level of interest rates. Although a decline in construction activity is also symptomatic of recession conditions, panelists believe both residential and commercial construction activity in the state will improve in 1982. It may well be that at current depressed levels, panelists believe construction is not likely to decline further; but the survey suggests positive reasons for expecting an improvement in construction as well.

Those reasons may be found in the generally optimistic outlook for aspects of the economy that determine costs for the producer and consumer. Foremost among these is the consensus that interest rates will decline slightly or moderately in 1982. Short- and long-run capital availability are also expected to improve, as are labor pressures. Table 1

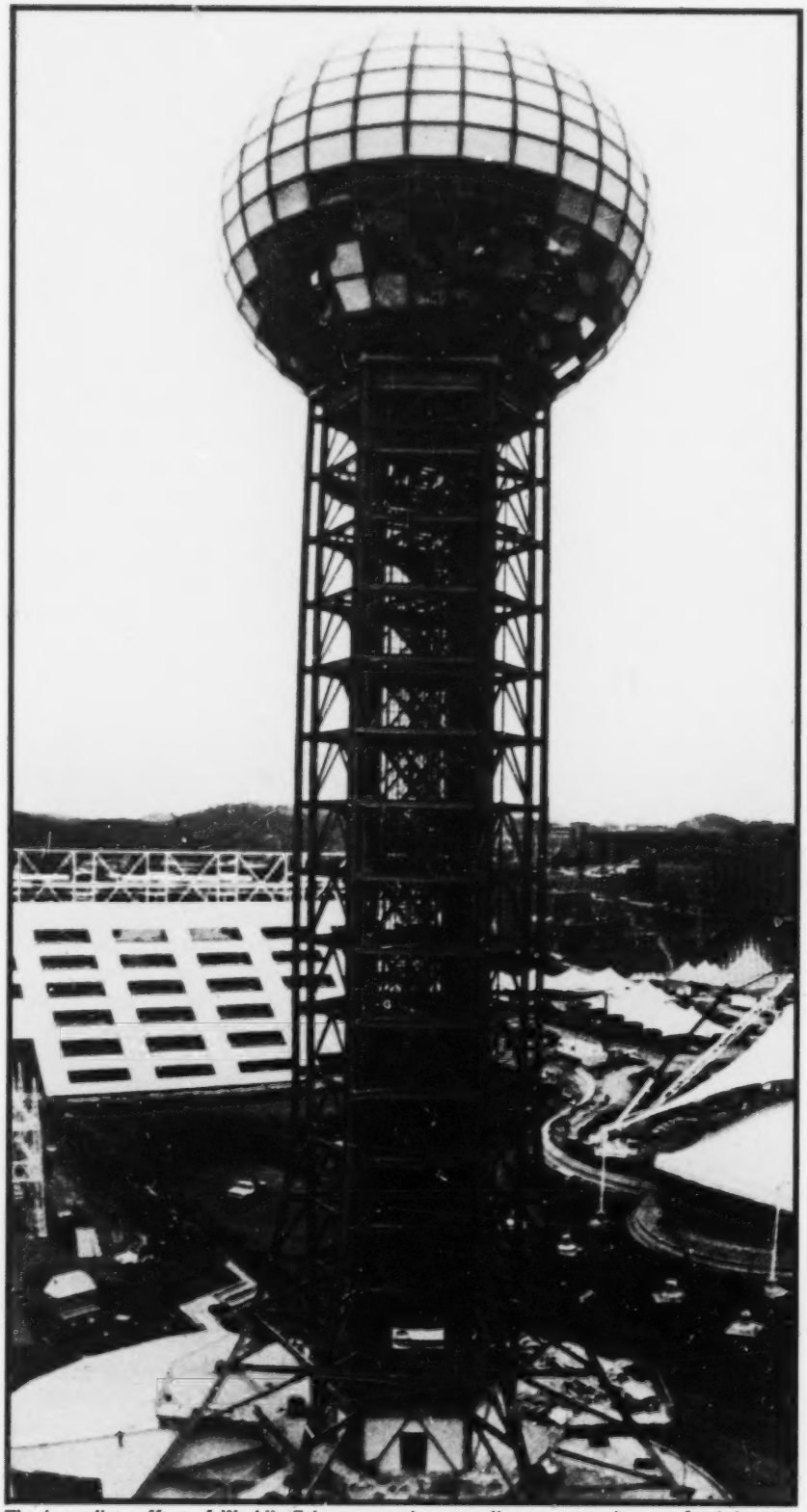
shows the areas which panelists expect to improve in 1982.

The expected declines in business costs, consumer price increases, and falling interest rates should improve the economy over the longer run. In agreement with many economists, a number of respondents comment that economic activity should pick up momentum in the last half of 1982. An East Tennessee manufacturer comments:

The most serious problem facing both Tennessee and the country is the immediate problem of the current recession. Unfortunately, this is an almost inevitable reaction to the longer-term problem of the Reagan Administration in bringing inflation under control and restoring sound, long-term growth. I don't think any more or different steps should be taken, and we'll just have to take our beating now. The tax cuts due in 1982 and other programs already enacted will turn the economy around by late 1982.

The nearly even split among the 1982 panel revealed in Figure 1 is based on rather different outlooks among the economic sectors represented among the panel. The respondents include manufacturers, members of the trade sector, finance, and an "other" group, comprised of construction executives, development officials, lawyers, and other professionals. On almost every issue this last group is notably more optimistic than other sectors. As Figure 2 shows, the financial sector tends to be the most pessimistic in its outlook for those recession-related aspects in 1982 — unemployment, plant utilization, consumer demand, and construction — but more optimistic with respect to declining cost pressures, which portend better performance in the long run.

The trade sector too is more pessimistic on some issues, especially with respect to consumer demand: 71 percent of the trade sector respondents believe consumer demand will be lower in 1982 than in 1981, compared to 23 percent of "other," 41 percent in manufacturing, and 39 percent in finance. One Middle Tennessee trade executive notes that recent recessions have been more severe in Tennessee



The immediate effect of World's Fair construction, spending on entertainment, food, housing, etc., will be readily apparent, but greater investment in plant and business activity will be of benefit to the state long after 1982. (Photo courtesy World's Fair News Center.)

than in many other parts of the nation and believes the present one is no exception. With respect to trade in particular, he says, **Because of our lower per-capita income (in Tennessee), our commerce will likewise be injured severely by the protracted recession.**

Key Economic Issues

The present recession makes the problems of the national and state economies more acute and many of these problems have been of ongoing concern to Tennessee's business community. Each year the Outlook Survey asks the panelists to rank the five most critical economic problems facing Tennessee in the year ahead. The list of most critical issues has been remarkably consistent in recent years, though a few have moved up or down in the rankings as conditions have changed. Figure 3 provides the key issues worrying the 1982 Panel. Interest rates, the problem ranked most critical in 1982, was also first in 1979 and 1981.

Despite the fact that virtually all the respondents expect interest rates to decline in 1982, they are still a problem. One Middle Tennessee banker notes that 1982's **greatest strength will be the lower level of interest rates. This will stimulate business, especially the building sector,** but, he adds, **even though rates are declining, they will remain at levels high enough to keep businesses with high credit needs from borrowing and expanding.**

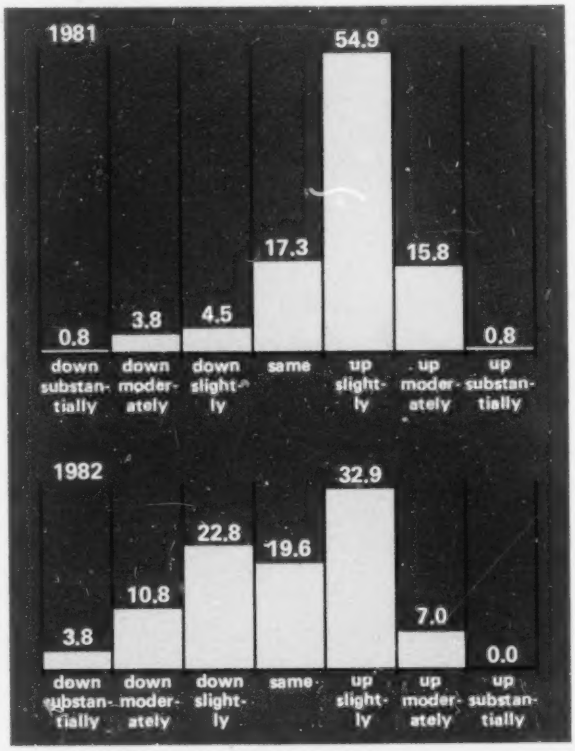
Energy costs and costs increasing faster than revenues have also been ranked consistently among the top 2 or 3 problems for the past five years, though they have been given slightly lower ranks this year. The particular problems confronting us now are reflected by the levels of construction activity and unemployment. Neither of these was considered a major problem by panelists in 1978, 1979 or 1980.

The 1982 panel anticipates the unusually high levels of unemployment to come in Tennessee in identifying unemployment as a key state problem. In this November survey, a banker from Middle Tennessee notes, **Unemployment, already at a high level, will continue to rise due to the sluggish economy.** He stresses the interrelatedness of the economic problems, saying that **Unemployment not only causes hardships for the individuals and their families, but also leads to higher crime, higher government deficits, and less consumer demand.** Aware of the rural areas that depend for their economic support on Tennessee's many apparel or auto component factories, for example, the banker believes that these rural areas will suffer the most adverse effects from the decline in industrial employment and the recession in general.

An East Tennessee attorney says, **Average unemployment of 8 to 9 percent in Tennessee in 1982 has to be the most dangerous economic problem we'll face. This may be a situation that has to be endured to correct the results of pernicious economic policies of past years.**

The links among the key issues in Figure 3 are underscored by another Middle Tennesseean — a manufacturer who sums up the present situation, saying, **Many of the above problems are interrelated. Interest rates need to come down in order to stimulate consumer**

1 Panelists are less optimistic about the state's economic growth than last year.



For 1982, their expectations are about evenly divided.

demand, which would in turn help employment and underutilization of plant capacity.

Panelists note that the present economic downturn and most of its underlying specific problems will not be resolved at the state level. A banker states, **A weakening in demand for goods and services will not allow firms to increase revenues sufficiently to offset inflation-related increases in the costs of doing business. Thus, profit margins will narrow. At the state level, nothing can be done to correct this situation.**

Patricia D. Postma is a Research Associate at the Center for Business and Economic Research, The University of Tennessee, Knoxville. She is editor of the **1980 Tennessee Statistical Abstract** and Data Processing Director for the Tennessee State Data Center.

Reagan's Economic Program

The survey reveals a clear consensus of support for President Reagan's economic program despite the fact that panelists feel results cannot be expected in the near term. Though there are mixed feelings about the size of tax cuts in relation to the deficit, the majority of panelists do not object to the program's impact on social expenditures.

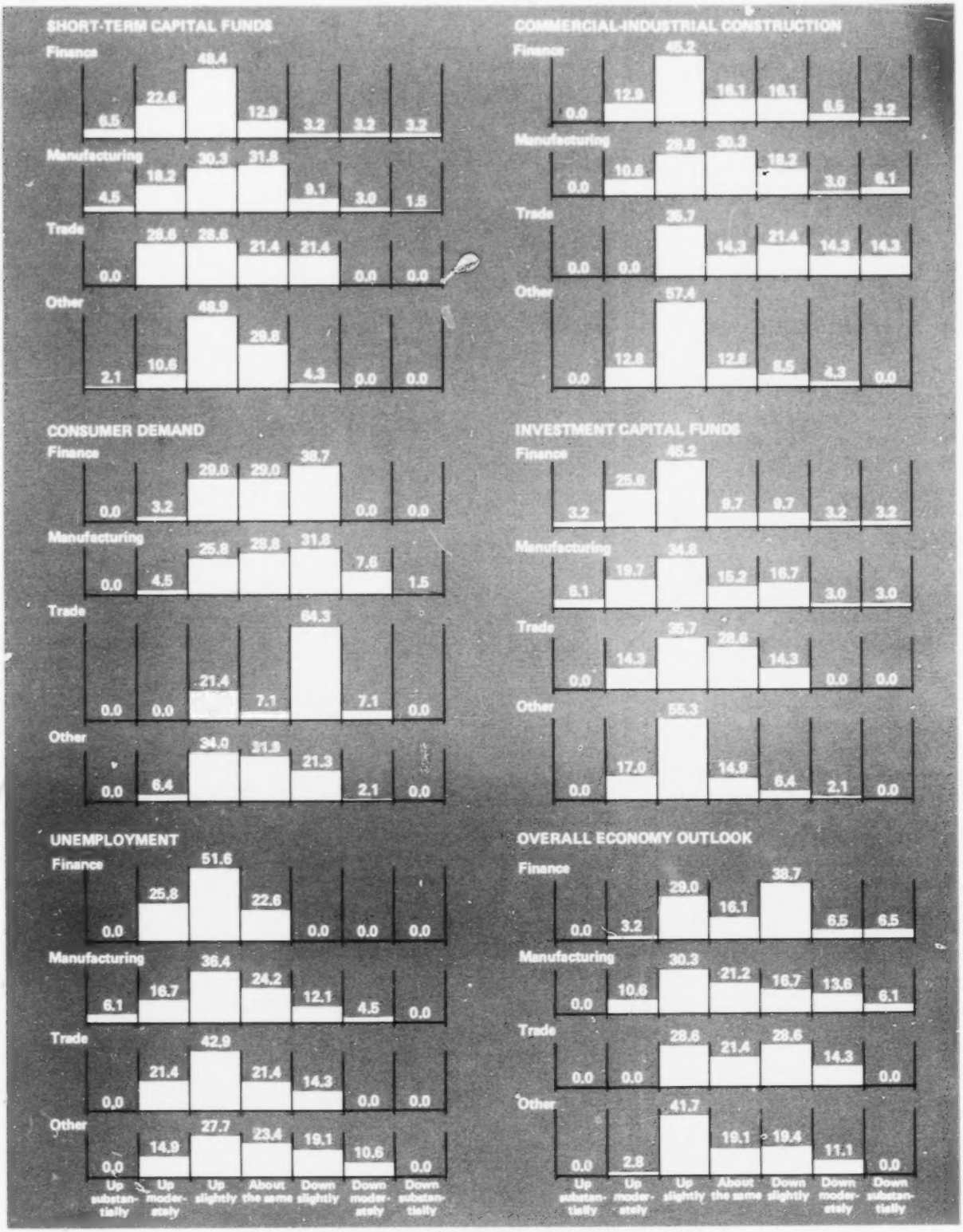
The questionnaire asks panelists to indicate how long it should take Reagan's program to achieve its objectives, assuming congressional cooperation and the moral support of the American people. Figure 4 indicates that they are somewhat less optimistic than the Administration itself, but two-thirds of the respondents expect it could be accomplished in four years. A banker's comment represents those of many panelists. He says, **There is no quick**

TABLE 1

EXPECTED AREAS OF IMPROVEMENT IN THE 1982 TENNESSEE ECONOMY
(Percentage Distribution of Panelists' Responses)

	Up Substantially	Up Moderately	Up Slightly	About the Same	Down Slightly	Down Moderately	Down Substantially
1. Interest rates on loans will be	0.0	0.0	1.9	5.7	48.7	33.5	7.0
2. The supply of capital investment funds will be	3.2	19.6	43.0	15.2	12.0	2.5	1.9
3. The supply of short-term working capital funds will be	3.8	17.7	39.2	26.6	7.6	1.9	1.3
4. Demands for wage rate increases will be	1.9	5.1	14.6	21.5	36.7	17.1	1.3
5. Labor-management problems will be	0.0	6.3	10.8	21.5	37.3	19.0	3.8
6. The supply of skilled workers relative to demand will be	0.6	10.1	46.2	31.0	7.6	1.3	0.6
7. Residential construction activity will be	1.9	10.1	36.1	24.7	13.3	8.9	2.5
8. Commercial-industrial construction activity will be	1.3	10.8	41.1	20.9	15.2	5.1	4.4

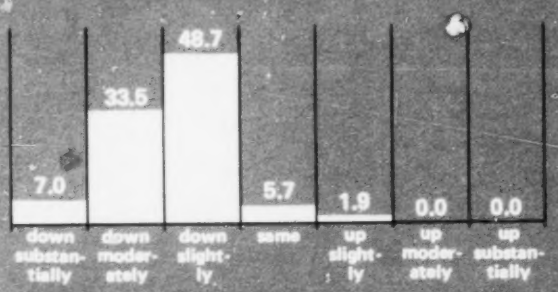
2 Expectations for Tennessee's economy varied widely by sector . . .



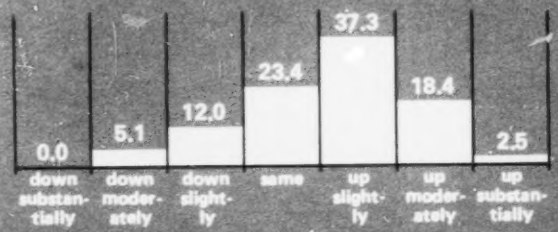
although nearly all respondents expect interest rates to go down.

3 Ranking of Key Economic Issues in 1982

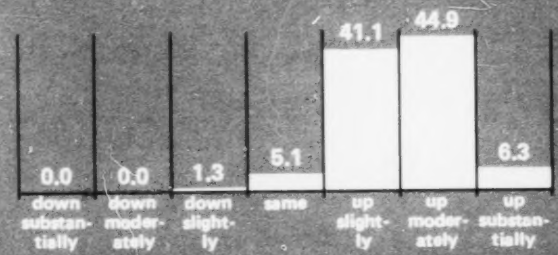
1. High interest rates are still a critical problem, and they underlie many of the other problems.



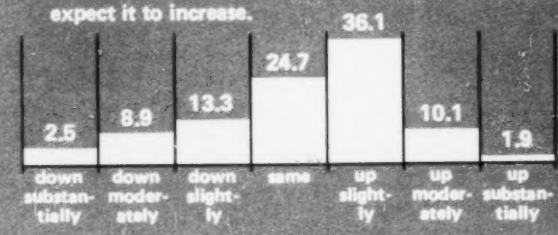
2. Unemployment is perceived as a much more serious problem for 1982 than it was in 1981.



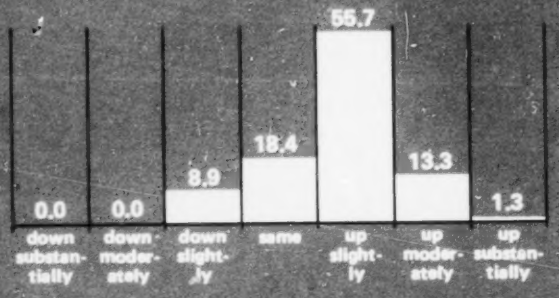
3. Respondents expect energy costs will continue to increase at troublesome rates.



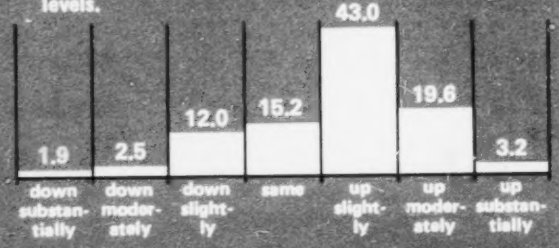
4. Depressed residential construction activity is a key problem in the economy, but the majority expect it to increase.



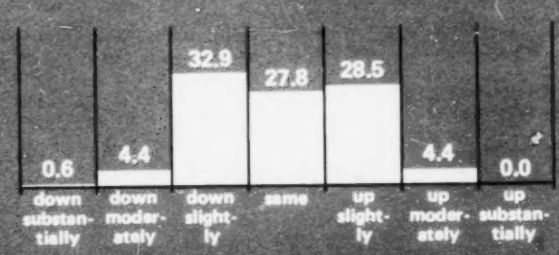
5. Business costs increasing faster than revenues remains a serious issue.



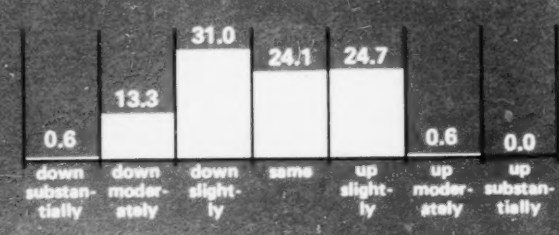
6. The supply of investment capital is a problem, though it should increase in 1982 above 1981 levels.



7. Low consumer demand is a problem, and many believe it could decrease further.



8. Plant capacity utilization, already low, is expected to be down further in 1982.



cure to ills that have been plaguing us for years. We are going to have to go through a time of turnabout before real economic growth can be restored.

More than 56 percent of the respondents think new depreciation allowances will stimulate investment in plant and equipment in 1982 to a moderate or substantial degree, while 87 percent believe those new allowances will stimulate capital investment over the longer run. Disagreement is voiced by one manufacturer who says, **I do not rate tax cuts as a primary motivation. Needs and outlook will determine investments — a tax cut is 'something extra'.**

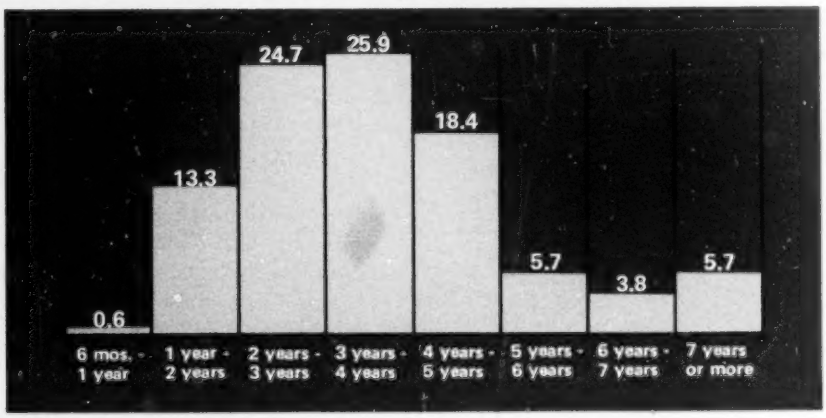
A question about the President's combination of tax cuts and expenditure levels reveals mixed feelings on the part of the panel. Of the respondents, 41 percent would have preferred smaller or no tax cuts as a trade-off for decreasing the deficit, while another 50 percent think larger spending cuts should have been used with the present tax cuts.

Though more than 70 percent of the panelists believe the budget cannot be balanced until the last half of the decade, 64 percent believe a balanced federal budget is extremely important, and 21 percent believe it is at least moderately important. The deficit impacts the availability of funds in the minds of the panelists. Responding to a question on federal borrowing, 70 percent believe federal borrowing "crowds out" private investment to a substantial degree. All four sectors respond similarly on this point and a representative of the construction industry speaks for most panelists when he says, **The federal government stands first in line at the loan window. As long as it requires such a high percentage of available loan funds, the private sector will suffer, both from cost and lack of availability.**

Two questions explore the panels' attitudes about the social impacts that may accompany the Administration's revenue and spending package. Here again, Reagan's program receives substantial support. More than 60 percent of the respondents believe the social programs of the past two decades have had substantial negative effects; 36 percent believe that they could be improved but should not be reduced considerably.

In response to another question, 34 percent concede that the losses in aid to the poor will not be returned to them by economic expansion, but 54 percent believe that the tax cuts are reasonable and that they will yield the desired expansionary benefits to the poor. Perhaps one manufacturer expresses the feelings of those who feel that the apparent social impacts are acceptable by saying, **The solution requires an attitude change in our society to prepare for lean times on occasion and restraint on the part of the news media and politicians who tend to fan the fires for quick cures.**

4 **Nearly 2/3 of the panelists believe Reagan's program could achieve its objectives within 4 years.**



Tennessee Fiscal Alternatives

One aspect of Reagan's program highlighted in his January budget message was, "The New Federalism." Federal budget cuts have already been felt in Tennessee at the state and local level, and the transfer of federal responsibilities will pose problems for many states. The 1982 panelists are asked a number of questions about Tennessee's fiscal alternatives. While a preference for our traditional tax structure is still predominant, a number of comments indicate the need for a new look at state government revenues. In the succinct words of a retailer, **I never thought I'd say this, but we must have a personal income tax!**

The pressures on state revenues are elucidated by panelists across the state. A Middle Tennessee manufacturer, remarking on the cutbacks in federal funding, notes that the state's **weakness in not formulating a realistic long-range tax program for future years has become apparent.** A panelist from East Tennessee emphasizes that **the tax structure in Tennessee is regressive, since it is heavily weighted by the sales tax. We need a mixture of income tax, sales tax (probably at a lower level) plus some review of other tax sources.**

The sales tax base is not only regressive, but inelastic. As one manufacturer points out, **The ratio of taxes to personal income is decreasing, thereby creating a problem of funding.** The retailer above believes a state income tax is a way of spreading the tax burden more equitably. **If we don't, the burden on business will become unbearable.**

Still, most of the panelists do not support a state personal income tax. Figure 5 shows that 54 percent do not favor instituting an income tax under any circumstances. Of the remainder

who are willing to consider an income tax, some prefer to keep other taxes at present levels, most prefer to trade off a decrease in sales tax, while others prefer to decrease property taxes.

Just as they support cutbacks in services at the federal level, many 1982 panelists believe some services should be cut at the state level. Although 48.7 percent of the respondents favor keeping the present level of services even if it means a tax increase, 46.2 percent would not favor maintaining present services if it requires a tax increase. However, respondents are not opposed to tax increases per se. A very high proportion — 73.4 percent — believe taxes should be increased *and* some services cut.

Changes in the Banking Laws

Along with the other regulatory changes of the recent past have been those in financial markets. Distinctions among credit unions, savings and loans, and banks are fewer than before, and money market funds, all-savers certificates, and IRA accounts have provided these institutions with the means to compete for savers' dollars. Panelists were asked whether these changes had led them to alter their business or personal accounts. Nearly half the respondents, 49.4 percent, have shifted funds from one kind of account to another within the same institution. The finance sector itself led the group with 71 percent shifting accounts. About 30 percent of the respondents have moved funds from one financial institution to another. There were understandably fewer institutional changes by the finance sector panelists, but about 40 percent of trade and "other" sector panelists have moved funds to other institutions.

Still other changes may occur in the next year or two. At present in Tennessee, intercounty banking is limited to bank holding companies which may open branch banks in metropolitan areas above 200,000 in population, or by merger with banks (in any county) that have been in existence at least 5 years. Savings and loans have been allowed to branch into other counties since 1980, and the state legislature is considering more liberal branching for banks. On the national level, many believe that the McFadden Act will be amended in the next few years to allow banking across state borders. Most panelists think such changes would be beneficial, though as Figure 6 shows, there were differences among sectors. The finance sector itself does not see such changes as beneficial. In citing the state's strengths and weaknesses several panelists believe conservative practices in the banking industry have been constraints on economic growth. One West Tennessean describes it as a **financial community with non-innovative, even provincial attitudes.**

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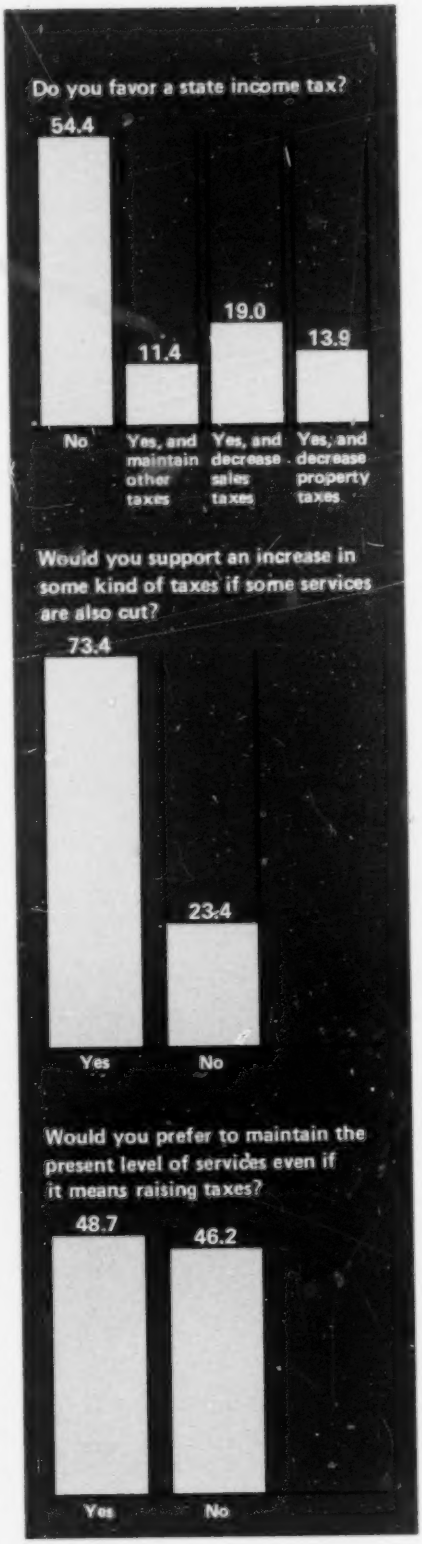


Panelists Look Toward the Future

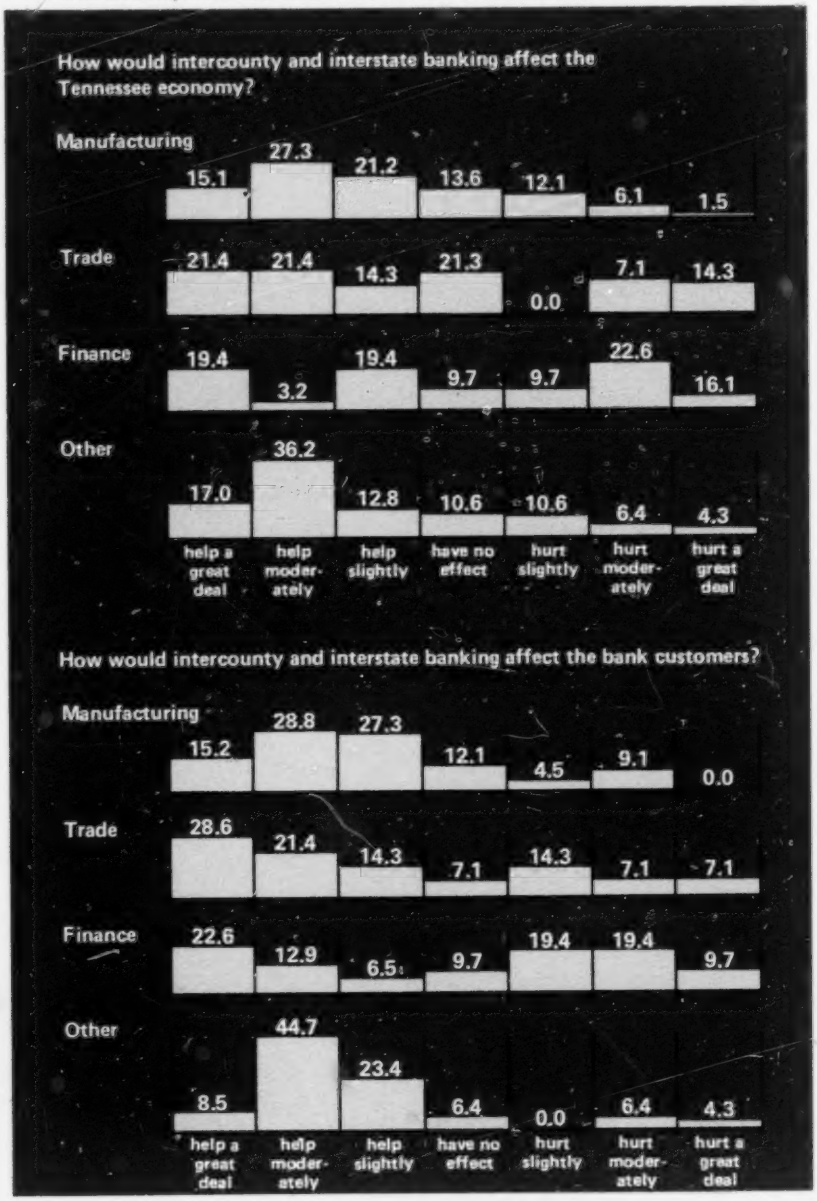
The current recession, with attendant unemployment, makes it unlikely that 1982 panelists commenting on the state's strengths and weaknesses would be as optimistic as the 1981 panelists; nonetheless, comments on Tennessee's relative strengths are common.

1982 is expected to have its bright spot — the World's Fair. Several East Tennessee panelists stress its regional benefits, and one also points out its broader effect. **The outlook for Tennessee and East Tennessee in particular is going to be helped in 1982 because of the World's Fair. The immediate effect of World's Fair construction, spending on entertainment, food, housing, etc. by tourists is readily apparent. But Tennessee is going to be exposed to the world on a basis never before experienced. The result should be greater investment in plant and business activities that will be of benefit to Tennessee long after 1982.**

Some panelists have an eye on the future in other ways, pointing toward desirable shifts to higher skill jobs and industries in the state. Two comment on difficulties of Tennessee's present industrial structure. As a representative of the state's large apparel industry, one manufacturer says, **In my market, we have dropped from a 2/3 share to a 1/3 share. Imports can now provide the quality, and I look for them to solve**

6

Most respondents believed allowing banks to operate across state and county lines would benefit the customer and the economy.



The finance sector was iess certain.

their shipping problems by fiscal 1984. This will hurt the garment industry further. A banker from West Tennessee comments on industry mix. **Tennessee's excessive sensitivity to national business cycles is due to our heavily manufacturing-oriented industry mix. Diversification will help increase both long-run growth and also mediate cyclical swings.**

A transportation executive relates unemployment to some fundamental problems, in addition to cyclical downswings. He states, **I believe unemployment of unskilled and semi-skilled persons is our most critical problem, and the primary cause is increasing sophistication in almost all areas of business. Skilled and management employees will be needed more and more.**

Echoing the same theme, a manufacturer says, **The skill level of workers is fundamental to improved productivity, quality, and sales. Improvement of attitudes and the skills of workers has no single solution. Improved technical and job skills courses in high schools and technical schools would yield immediate gain. Some private trade schools in Tennessee seem to produce more effective technicians than any public school. This need not be. Better equipment (word processors, automatic test equipment, etc.) offers more opportunity to up-grade skills.** The same panelist cites Tennessee's advantages of central location, energy availability, and quality of life, noting that they will continue to bring gradual progress, but **I suspect major change will not occur until greater utilization is made of the considerable technology base of TVA and the Department of Energy.**

Though these 1982 panelists recognize the uncertainties presently facing the nation and the state, they recognize as well the need to take the long view, and there is an underlying assumption that the problems will be solved. **A patience and willingness to endure temporary difficulties; a recognition that we should view both the state's services and taxes in a new light; and a belief that diversification and upgrading of our industrial mix is desirable: these should enhance the state's fundamental strengths in 1982 and beyond.** ■

Outlook for Tennessee and the Nation

William F. Fox

The economic forecast for 1982 reflects a significant shift towards pessimism for the short-term performance of the Tennessee economy, resulting mostly from a large downward adjustment in the national assumptions used in the Tennessee Econometric Model. Also, the continued performance of the Tennessee economy at a level below the national economy is reason for pessimism, although all economic news is not bad, since the inflation picture is now brighter.

Recent Tennessee Economic History

The past two years have been a period of sustained economic stagnation in Tennessee. It is fair to say that the Tennessee economy declined substantially during the recession of 1980 and has not yet rebounded. The number of nonagricultural jobs in Tennessee declined by 88,000 from November 1979 to November 1981, representing a 4.9 percent decline in jobs. The stagnation is characterized by its duration, diversity, and its depth relative to the U.S. Duration is an important characteristic of the economic stagnation. Tennessee began to experience the existing economic conditions in early 1980 and has remained in a negative or no-growth position throughout. Further, our forecast is for similar economic conditions for the next year.

The downturn in Tennessee economic conditions has been much deeper than that for the U.S. as a whole. Over the two-year time period, nonagricultural jobs increased 1.6 percent in the United States as they were declining 4.9

percent in Tennessee (see Figure 1). During December 1981, the nonseasonally adjusted unemployment rate for the United States stood at 8.3 percent in the United States and 10.4 percent in Tennessee,[1] the highest recorded rate for the state.

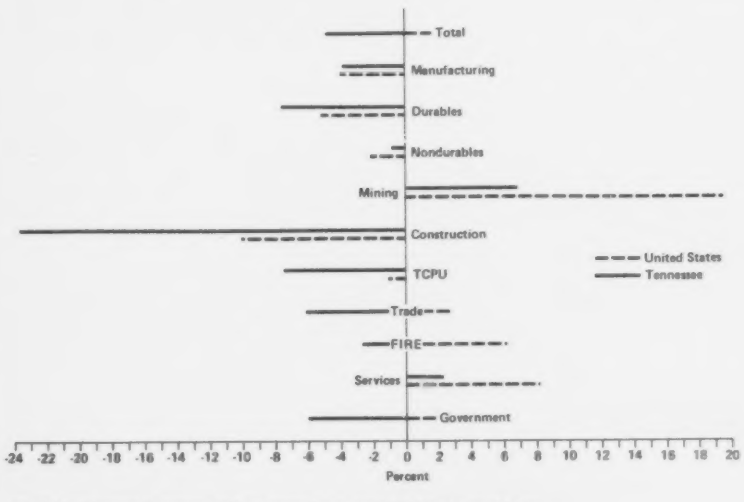
Several factors should be noted about the unemployment rate. First, all of the increase cannot be attributed to the economic downturn. The high level results both from a decline in jobs and an increase in the labor force (about 1.5 percent per year over the past two years).[2] Second, the full employment unemployment rate – the unemployment rate that results when the labor force is thought to be operating at full capacity – has been rising over time as a result of large numbers of new entrants into the labor market. Thus, the level of unemployment rates is indicative of a less severe problem than in the past.

The reasons for the depth of the stagnation become clear from an analysis of the diversity. Over the past two years only two sectors, services and mining, experienced growth in jobs, both at growth rates considerably below the national average (Figure 1). Manufacturing, the sector generally expected to decline in a recession, has lost employment, but at a rate lower than the state's average. Durable industries, particularly transportation equipment; stone, clay, and glass; lumber and wood products; and the nondurable rubber and plastics industry have suffered the greatest job losses. It is important to note that the larger downturns in manufacturing began only in the last several months; therefore, manufacturing will appear much worse off several months from now.

Construction job losses have exceeded 20 percent and are much worse than the losses around the U.S. The big downturn in construction results mostly from high interest rates but also reflects the poor general condition of the economy and the resulting weakness in construction demand.

The other nonmanufacturing industries are the key to Tennessee's dismal performance in 1979-81. Wholesale and retail trade jobs declined by 6.2 percent. Big losses appear to have occurred in jobs at automobile, building supply, and farm implement dealers. Discouraging effects of high interest rates on durable sales and lagging income growth are two significant reasons for the decline.

FIGURE 1
PERCENT CHANGE IN EMPLOYMENT, UNITED STATES AND TENNESSEE, NOVEMBER 1979-1981



SOURCE: Tennessee Department of Employment Security and U.S. Department of Labor.

Government Sector

The government sector, which has generally been counter-cyclical through previous recessions, has been pro-cyclical in the past two years. Government sector job losses have exceeded 6.0 percent, with the largest decline occurring in the federal government. Federal job losses are undoubtedly largely the result of cutbacks in TVA power plant construction and reductions in federal programs that utilize field staffs.

State and local government job losses emanate from constant dollar revenue declines. Elimination or reduction of federal programs that aid subnational governments is an important reason. The other reason is the low elasticity of state government revenues. The long-term income elasticity of revenues in Tennessee is approximately 0.9. But the elasticity varies widely over the business cycles and is particularly low during economic downturns. The own-source revenue elasticity was .51 between fiscal year 1979 and 1981.

The only solution to the wide swings in revenue elasticities is to develop a more balanced revenue structure. That means the dominance of consumption-based taxes, which now raise 71 percent of own-source revenues, must be reduced. A low rate personal income tax combined with a reduction in the sales tax would achieve this objective.

Declines in jobs in the transportation, communications, and public utilities (TCPU) and finance, insurance, and real estate (FIRE) sectors also occurred. Transportation declines as a result of downturns in manufacturing help explain the difficulty in TCPU. High interest rates, poor construction, and low retail sales explain the problems in FIRE.

FORECAST ASSUMPTIONS

Reaganomics

The main tenets of Reaganomics are adherence to supply side economics and tight money. Supply side economics involves giving incentives to stimulate

work effort, savings, and investment in order to give economic agents a greater incentive to produce goods and services. Thus, the President's tax package cuts marginal income tax rates to encourage workers to labor more and more productively. Saving is encouraged through new regulations concerning individual retirement accounts (IRA) and all savers certificates and through the potential for higher income. Investment is encouraged by faster depreciation write-offs.

Supply side economics can be contrasted with the better-known demand side or Keynesian economics. With Keynesian economics, demand management is used to insure that aggregate demand (the sum of consumers, businesses, and government, and net international purchases) is at the full employment level. The weakness in using demand side stimulation is that the supply side may respond either through output increases or price increases (inflation) and still equal the demand. Output responses, as opposed to inflation, occur only when people and business have the incentives to produce more.

Both demand side and supply side economics can be useful in the proper economic climate, and in many circumstances a mix of policies may be needed. In the current climate of high inflation and low productivity, supply side economics offers the potential to increase the levels of output and seems generally appropriate, but the administration has oversold the potential benefits of this approach. The incentives will stimulate increased economic activity but will be insufficient to create major adjustments in the economy. This is particularly true in the short run, since supply side economics must operate through changes in behavior and expectations, which are likely to occur only after a period of time. Thus, the inability of supply side economics to create immediate successes is to be expected, and rapid responses to the President's program should not have been anticipated.

The difficulty with the supply side approach as it has been implemented is that budget cuts of the magnitude necessary to bring the budget closer to balance have not been forthcoming. Balanced budgets are not a magic formula for economic success, but the large deficits are absorbing funds that otherwise could be used for business investment and are one source of high interest rates. The fiscal 1982 federal deficit will likely be in the range of $100 billion (see Figure 2). The forecast is based on the assumption that the Reagan Administration gets $45 billion in unspecified expenditure cuts in 1983 and $54 billion in 1984. Even with these assumptions, which are somewhat difficult to accept, the deficits are about $90 billion for each of those years. If the expenditure cuts are not made, the deficits will be far in excess of $100 billion. Significant reductions in the deficit can be made only if entitlement programs, social security, or defense spending are dramatically reduced.

Tight money, the second tenet of Reaganomics, is supported by the Administration as a mechanism to bring inflation under control. The idea is to avoid monetizing the inflation by providing insufficient dollars to sustain existing levels of inflation. Our assumption is that the Federal Reserve will continue its policy of tight money and will be effective in bringing down the rate of inflation slowly over time.

Some economists have proposed adoption of the gold standard in order to take control of the money supply out of the Federal Reserve's hands. The Reagan administration appears unlikely to support the gold standard, since this strategy is likely to be counterproductive. One concern is that control

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FIGURE 2

1970-1989 FEDERAL DEFICITS

SOURCE: Wharton Econometric Forecasting Associates, Inc. Wharton Annual and Industry Forecasting Model, Historical Data and December 1981 solution.

of the gold supply is outside the U.S. More importantly, it is difficult to believe that the gold standard would work effectively when other countries around the world were not cooperating.

Inflation

Inflation, as measured by the gross national product deflator, will be 8.7 percent in 1982, compared with 9.2 percent in 1981. Over the remainder of the decade, the inflation rate will fall slowly, with the rate being a little above 7.0 percent at the decade's end. This represents a shift towards optimism in the government's ability to control inflation.

The average inflation rate is forecast to be 8.0 percent annually over the decade, compared with last summer's forecast of an 8.3 percent average. The inflation forecast is based on the assumption that there will be no shocks in energy prices such as occurred in 1973-1974 and 1979-1980. Petroleum prices are assumed to grow at a rate several percentage points faster than the GNP deflator. Dramatic price increases are expected in natural gas prices, primarily as a result of deregulation, with the greatest increases expected to occur in 1985-87.

FIGURE 3

U.S. SHORT-TERM AND LONG-TERM INTEREST RATES, MONTHLY, 1976-1981

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, January issues, 1977-1981 and November 1981.

Interest Rates

The forecast for a slow rebound from the current recession is based heavily on the anticipation of higher interest rates later in 1982. This assumption comes on the heels of the 576 basis point (one basis point equals one 100th of a percent) drop in the federal funds rate between August 21 and December 25, 1981 (See Figure 3 for trends in interest rates). This decline was mainly a result of falling demand for funds, with the money supply growing at a 5.7 percent annual rate during the intervening time. The expectation is that interest rates will rise again in the second half of the year as the government borrows to fund the deficit, people increase their demands for borrowed funds after the July 1, 1982 tax cut, and businesses increase their investment goals. Thus, rising interest rates will prohibit a swift rebound. The level of rates, however, will remain below the 1981 highs because the inflation component of interest rates will be smaller.

Election year considerations will bring pressure on the President to seek ways to keep interest rates lower. Some have already suggested that the Federal Reserve should boost the money supply growth rate to keep interest rates from rising, and others are likely to join in the chorus. Such an action may lower short-term rates for a brief period. As the market becomes aware of the money supply increase, however, the anticipation of inflation will cause lenders to demand higher rates. Therefore, no sustained cut in rates can be achieved by the Federal Reserve as long as inflation expectations can offset selected policies. Further, the gains made in reducing the inflation rate will be lost, and the inflation forecast discussed above will be unachievable.

Declining inflation rates will eventually mean falling interest rates. Long-term interest rates should fall to near 10 percent by the decade's end, based on the inflation forecast. Falling interest rates will permit the pent-up demand for housing and automobiles to be satisfied in the 1983-1985 time period, providing a strong stimulus to the state's economy.

Short-term Forecast

The Tennessee economy is forecast to continue in a very stagnant condition during 1982. Real Tennessee gross state product (GSP) is forecast to grow only 0.4 percent during the year, slightly slower than the forecast for gross national product (Table 1). At the end of 1982, constant dollar GSP will still be below the 1979 level. Though

the Tennessee Econometric Model does not currently have the capability to forecast quarterly economic activity, a likely set of events would be for the first quarter to exhibit negative growth, the second quarter to show no change, and the final two quarters to be characterized by slowly increasing growth rates. As noted above, the rebound in the second half will be slow as interest rates rise.

Nonagricultural jobs will experience the third consective year of negative growth in 1982 (see Table 1). The unemployment rate is forecast to continue rising and to average 8.9 percent for the year, exceeding the previous high of 8.5 percent recorded in 1981 (see Table 1). A comparison of 1971-1980 data and 1981-1990 forecasts is provided in Figure 4. High averages will probably result from unemployment rates above 10.0 percent for the first several months, followed by declining rates over the remainder of the year. If rates fail to drop quickly after the first quarter, the average for 1982 will exceed the forecast level and average over 9.0 percent.

The continued rise in the unemployment rate results from growth in the labor force rather than declines in employment (as opposed to nonagricultural jobs). The aggregate number of unemployed persons will reach an all-time high in 1982, though it must be remembered that the labor force will also be at an all-time high.

Personal income is forecast to grow slightly under 10.0 percent in 1982, amounting to less than 1.0 percent in constant dollars (see Table 1). In nominal dollars, income is forecast to increase less than any year since 1975. Very slow wage growth is a significant factor in the 1982 income trend. The wage growth is anemic because labor's ability to seek significant raises from business will be limited in the poor economic climate. Labor may even begin to make some concessions, as

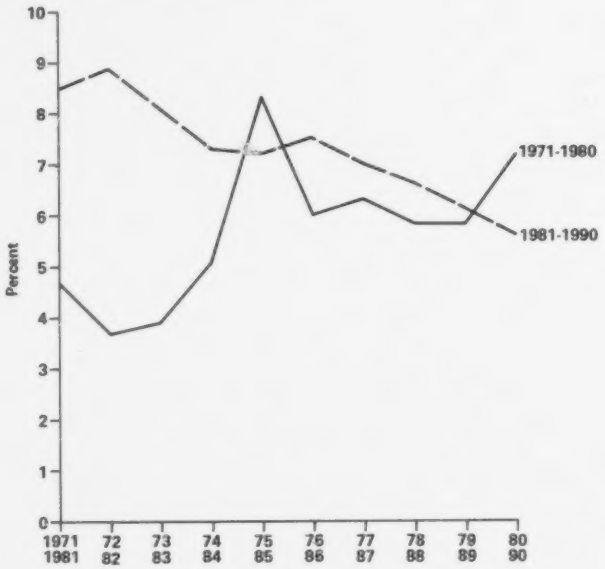
TABLE 1

STATE AND INDUSTRY SELECTED VARIABLES: QUANTITIES AND PERCENT CHANGE FROM PRECEDING YEAR, 1982–1984 AND AVERAGE ANNUAL PERCENT CHANGE, 1984–1990

	1982	1983	1984	1984-1990
U.S. Gross National Product				
(Billions of 1972 dollars)	1,516.9	1,579.7	1,640.2	
Percentage Change	0.54	4.14	3.83	2.79
Tennessee Gross State Product				
(Millions of 1972 dollars)	27,017.2	28,068.5	29,236.7	
Percentage Change	0.40	3.89	4.16	2.99
Tennessee Personal Income				
(Millions of 1972 dollars)	20,444.6	21,040.1	21,688.1	
Percentage Change	0.77	2.91	3.08	3.55
Tennessee Nonagricultural Jobs				
(Thousands)	1,716.0	1,757.0	1,803.0	
Percentage Change	-0.13	2.39	2.62	1.57
Tennessee Manufacturing Output				
(Millions of 1972 dollars)	9,931.5	10,507.6	10,958.2	
Percentage Change	-0.04	5.80	4.29	2.72
Construction Employment				
(Thousands)	68.6	74.0	81.1	
Percentage Change	-2.29	7.90	9.52	2.38
Tennessee Retail Sales				
(Millions of 1972 dollars)	10,480.	10,917.	11,418.	
Percent Change	3.02	4.17	4.59	3.31
Tennessee Electricity Consumption				
(Millions of kilowatt-hours)	51,805.	52,594.	53,669.	
Percentage Change	0.43	1.52	2.04	2.02
Tennessee Unemployment Rate	8.9	8.1	7.3	–

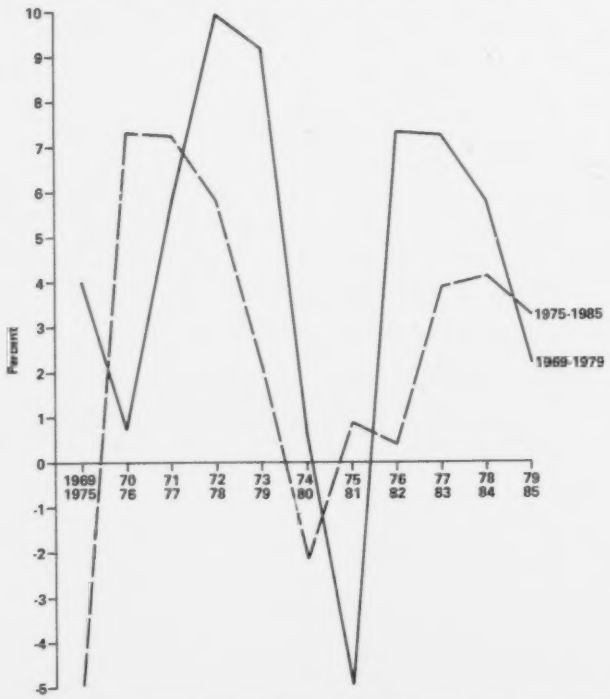
SOURCE: Tennessee Econometric Model, January 1982 solution.

FIGURE 4
TENNESSEE UNEMPLOYMENT RATES, ACTUAL 1971-1980 AND FORECAST 1981-1990



SOURCE: Tennessee Econometric Model, Historical Data and January 1982 solution.

FIGURE 5
GROWTH RATE OF REAL GROSS STATE PRODUCT



SOURCE: Tennessee Econometric Model, Historical Data and January 1982 solution.

already discussed by leaders in the automobile industry, in order to make U.S. businesses more competitive with foreign business.

Declines in real output are forecast for the durable goods manufacturing, construction, and government sectors. These same sectors, plus trade and transportation, communications, and public utilities (TCPU), are also forecast to experience losses in jobs.

The tax cuts legislated for July 1, 1982, and July 1, 1983, falling inflation (and therefore declining interest rates), and the already legislated business tax cut will be the prime movers in stimulating an upturn in the economy. The upturn will begin slowly in the second half of 1982, but will not be reflected in the annual statistics until 1983. Output in Tennessee is forecast to grow just under 3.9 percent in 1983. This is a strong year, but considerably under the 7.3 percent rebound that followed the 1974-1975 recession. Figure 5 illustrates the duration and rebound surrounding the 1974-1975 recession and the forecast for the 1980-82 recessions.

The strongest growth will occur in the industries that are most sensitive to recessions and high interest rates. Constant dollar construction is forecast to grow 9.0 percent, but still remain below the 1979 level. Manufacturing will exhibit a strong rebound, with the fastest growing durable goods sectors including lumber and wood products; furniture and fixtures; and stone, clay, and glass, and the fastest growing nondurable goods sectors being apparel, textiles, and rubber and plastics.

Nonagricultural jobs will show positive growth in 1983 for the first time in four years, with the forecast calling for 2.4 percent growth. Nonetheless, there will be almost 20,000 fewer jobs than in 1979. Every sector except government and manufacturing is forecast to experience above-average employment growth (mining will be slightly below average). The forecast manufacturing growth rate of 2.1 percent is well above the anticipated long-term trend.

The unemployment rate will fall

rapidly through 1983 and average 8.1 percent. The number of persons employed will increase so rapidly that the new entrants to the job market can be absorbed and the number of unemployed cut.

Personal income growth will be nearly 3 percent in real terms. One reason is stronger growth in wages and salaries, though this growth will remain weak by historic standards.

Sustained economic growth will continue into 1984 as the impacts of the tax cuts and declining interest rates stimulate an additional rebound from the recession (see Table 1). Nearly every economic sector will exhibit rapid growth in output and employment. The unemployment rate will drop dramatically to 7.3 percent as the economy experiences the best growth since 1978.

TABLE 2

TENNESSEE REAL GROSS STATE PRODUCT AND NONAGRICULTURAL JOBS COMPOUND ANNUAL GROWTH RATES

	1971-1980	1981-1990	1983-1990
Tennessee Gross State Product	3.78	2.92	3.15
United States Gross National Product	3.13	2.80	2.93
Tennessee Private Sector Output	3.74	3.11	3.32
Tennessee Public Sector Output	3.83	1.49	1.79
Tennessee Manufacturing Output	3.87	2.92	2.94
Tennessee Nonagricultural Jobs	2.76	1.58	1.72

SOURCE: Tennessee Econometric Model, Historical Data and January 1982 solution.

Long-term Forecast

After 1984, a generally sound growth trend is forecast. A slowdown is reflected in 1986 and 1987 as an inventory adjustment and in recognition of the somewhat regular pattern of business cycles. Overall, the decade is forecast to be characterized by moderate growth.

The economic forecast for this decade (1981-1990) is for slower growth than in the past decade (Table 2). Part of the reason is the very slow growth trend forecast for 1981 and 1982. The years 1983-1990 are forecast to be closer to that of the past decade. It should also be noted that the U.S. GNP growth rate is expected to slow. Tennessee will continue to outperform the nation in economic growth over the next decade.

The reasons for slower growth in Tennessee are evident from the last four lines in Table 2. The most important reason is the dramatic slowing of jobs growth. Nonagricultural jobs increased 2.76 percent annually over the 1971-1980 decade, and are forecast to grow 1.58 percent in the following decade. However, this does not result from weaker demand for labor, but instead is a reflection of significant demographic shifts. Lower growth in first entrants to the labor force is one reason, because most of the baby boom children have already entered it. Numbers of women entering the labor force are also expected to decline, as the participation rate now nears 52 percent in the U.S. The lower growth in jobs is more than sufficient to cause the lower growth rate of GSP, meaning that the other component of output growth, productivity, is forecast to do better in the next decade than in the past.

Forecasts for several specific sectors are also important for understanding the anticipated GSP trend. The public sector, including federal, state, and local governments, is the most prominent. Weak revenue growth for Tennessee state and local governments, described above, and cuts in federal aid are two factors. Finally, lower electricity growth and construction cutbacks will slow TVA growth. Thus, this sector, which grew faster than average over the past decade, will slow dramatically. The coming decade's growth for this sector is forecast at 1.5 percent annually, compared with the 3.8 percent of last decade.

The private sector, on the other hand, is forecast to do much better compared with the past. Manufacturing is an exception, because it is expected to experience a more dramatic slippage and perform as an average industry in Tennessee during the coming decade. The maturing of this industry in the U.S. leads significantly to this forecast. Employment in manufacturing is expected to grow less than 0.3 percent annually in the U.S. during the 1980's. The existing heavy concentration of this sector in Tennessee also makes it difficult to achieve rapid growth. Still, successes in attracting manufacturing firms to Tennessee are expected, and more rapid growth is forecast for the state.

The unemployment rate is forecast to continue declining over the decade (Figure 4) due to slower growth in the labor force and healthy employment growth. The unemployment rate will remain historically high, but this is not surprising in light of the expected mix of young people and women in the labor force. ■

1. Care must be used in comparing national and state statistics. Tennessee unemployment rates are always unseasonally adjusted, whereas both seasonally and unseasonally adjusted data are reported for the U.S. The unseasonally adjusted unemployment rates must be used for comparisons.

2. The unemployment rate is calculated using employment data rather than the nonagricultural jobs information noted above. These data series differ because of different coverage, multiple job holding, and state residence.

Outlook for Specific Industries

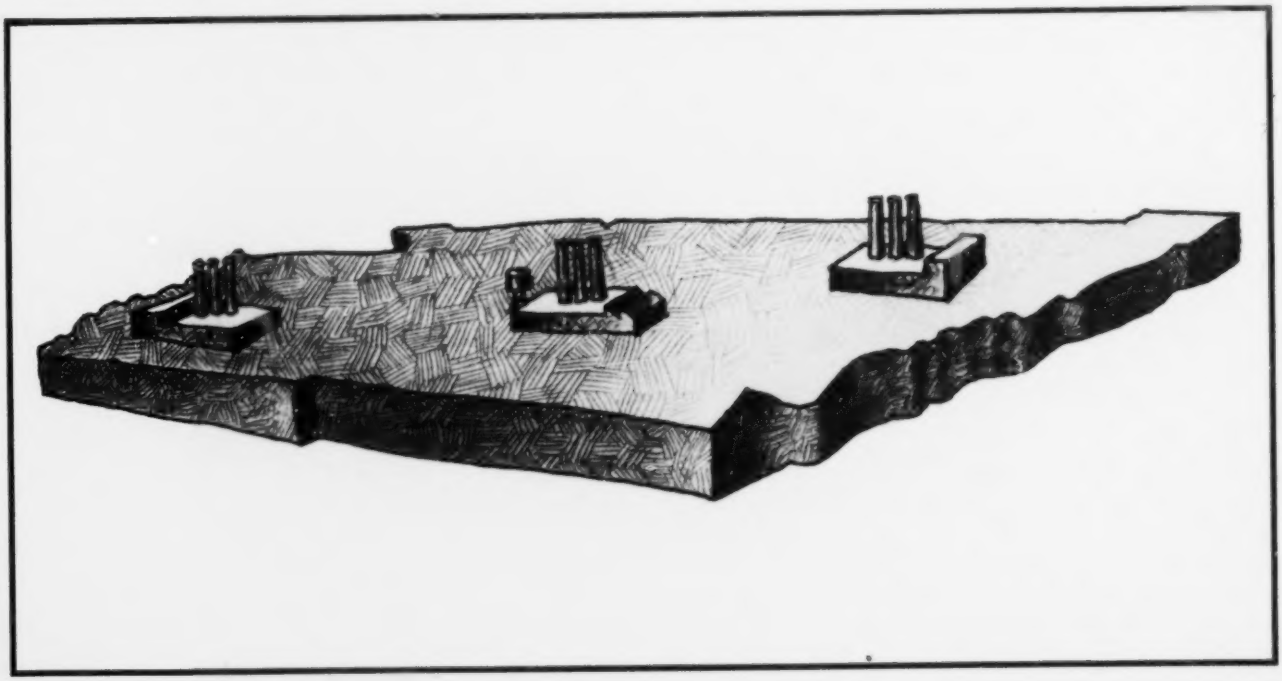
Richard Hofler, John Mayo, Patricia Postma, and Niles Schoening (Ed. by R. Hofler)

Overview

Effects of the dismal slide through which the Tennessee economy has traveled to its present low point have permeated every sector. Indeed, the state's inability to recover from the mild recession in the first part of 1980 has undoubtedly been attributable to the unusual and continuous decline in trade and the low growth rate in service — normally considered "recession-resistant." Nor does the coming year promise a strong turnaround. As the preceding article notes, real GSP is forecast to increase less than 0.5 percent during 1982, while employment increases less than 0.1 percent.

There are an unusual number of recent changes in policy, in institutional arrangements, and possibly in underlying economic relationships, which, though exogenous to Tennessee's economy, affect its various sectors in important ways. In addition, the present economic difficulties have bared fundamental fiscal problems for Tennessee's state and local governments which will not be easily resolved. The total effect of these circumstances is to make the present recession more severe than any in the postwar period — in every sector — and the recovery slower. Furthermore, the effects of the present changes are far from working themselves out. In such an environment, long-term econometric forecasting requires more than the usual amount of perspicacity.

The following sections on Tennessee's economic sectors discuss their current and projected economic performance. Perhaps more important, in each case we have attempted to



identify the factors which contribute such an unusual degree of uncertainty to the present situation. The remainder of this overview reviews the trends of the recent past and briefly highlights the uncertainties and the forecasts for the various sectors.

Growth of Nonmanufacturing Sectors

Tennessee has been and continues to be an important manufacturing economy. One of the most distinct long-term changes, however, both nationally and in the state, has been the growth of the nonmanufacturing sectors of the economy. These sectors have not only provided long-term sources of growth over the past few decades, they have proved to be resistant to cyclical downswings. In the past, Tennessee has had a smaller proportion of its economic activity in these nonmanufacturing sectors than has the United States as a whole. Relatively faster rates of growth in these state sectors have lessened the disparity. During the 1970's, state and local government expenditures increased by 180 percent, while employment increased by 30 percent. The public sector growth was uneven, however, as tax collections grew by large amounts only because of increases in the tax rate in 1968, 1972, and 1977. This expansion in tax collections allowed the expansion in expenditures and employment.

The trade sector has experienced uncharacteristic declines through 1980 and 1981, and growth in services has slowed to an unusual extent. Federal, state, and local fiscal constraints, added to the large layoffs caused by cutbacks in the TVA's nuclear construction program, have caused a loss of 8,700 jobs in the government sector between 1980 and 1981 (see Figure 1). Transportation, communications, and public utilities (TCPU) showed employment declines in 1980 and 1981, while nominal output showed the smallest increase of the past ten years between 1980 and 1981. Finance, insurance, and real estate (FIRE) experienced a decline in both real output and employment in 1981. Added to these unusual declines in sectors considered "recession-resistant" are the drastic downturns in the traditionally volatile sector, construction. Employment in the construction industry dropped 13.9 percent in 1980 and another 8.6 percent in 1981. Manufacturing experienced a small decline in 1979 and nearly 4.0 percent decline in 1980, but managed to add jobs in 1981.

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1982 will bring only slight improvements, since the national and state economies are not expected to turn up until the second half of the year. Manufacturing, mining, services, and FIRE are expected to post modest gains in employment by year's end, while trade, services, FIRE, TCPU, mining, and agriculture post modest gains in real gross product. Both trade and services will be stimulated by heavy demands from World's Fair business in the Eastern part of the state.

Growth Expected by 1983

By 1983, growth is expected to be strong in all sectors, both in terms of output and employment. Peak years of growth for most sectors during this expansion occur in 1984 (see Table 1, p. 18) though the expected downswing in 1985 and 1986 is mild, and unlike most downswings, it leaves nearly every sector with modest gains.

Despite the healthy growth through 1985, employment lost in the current recession will not be rapidly recovered. Though downturns from 5 to 7 years apart appear to be a normal feature of business activity, the depth of the current declines, as well as the confluence of several economic changes, means that regaining the lost ground in some sectors will take most of the coming decade.

What are the uncertainties in the present period that make the rate of recovery slow and forecasting more difficult? Many have to do with the President's economic policies. Deregulation of airlines, trucking, and railroads, and those pending in communications, will continue to alter the structure of these industries. Air transportation has already been cut in many Tennessee markets, while some new, small lines have entered the market. The recent court decision with respect to AT&T will certainly alter prices in the short run and possibly encourage competition in local markets in the long run. Budget deficits, inflation, and the Federal Reserve Board monetary policy have kept interest rates high and mortgages out of reach for many, and it has also affected the purchase of durable goods. Ironically, though inflation is decreasing, an upturn in the economy in 1983, coupled with intractable budget deficits, may prevent interest rates from dropping to the low levels of the 1970's.

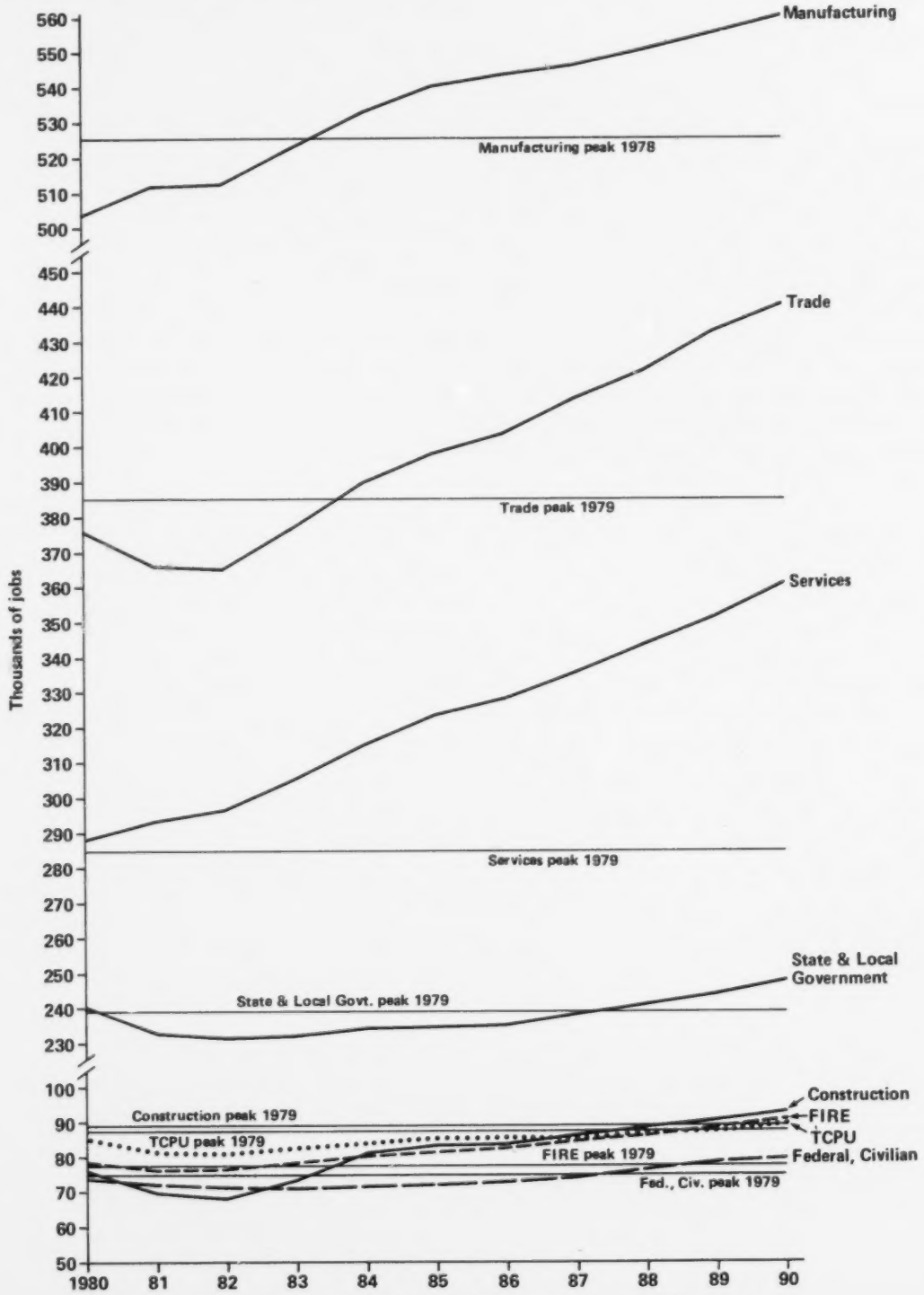
Effects of Deregulation

Financial institutions may undergo substantial changes in the 1980's as the effect of deregulation on commercial banks, savings and loans, and credit unions continue to work themselves out, and as innovative packages of investment instruments with high liquidity are devised by all participants. Rapid change in electronic transfer of funds is another force which may restructure financial markets over the next decade.

Upheavals in the international

FIGURE 1

NUMBER OF JOBS BY SECTOR: 1980 ANNUAL LEVELS RELATIVE TO PEAK LEVEL OF THE 1970's



SOURCE: Tennessee Econometric Model, Historical Data and January 1982 solution.

energy market in the early 1970's have apparently permanently altered the relationship between energy consumption and economic growth. In Tennessee, one consequence of that change has been the deferral of planned nuclear plants in 1979 and 1981 and the layoff of several thousand construction workers in 1981. At present, the deferral of three other plants is under consideration, and there will be a further employment impact if they are, in fact, deferred.

Clearly, one serious state problem is the fiscal squeeze on state and local governments. Despite healthy growth in the state's economy in the 1970's, real own-source revenues in Tennessee have not grown significantly except when tax increases have been enacted. Tennessee's present tax structure, based on consumption taxes, motor vehicle fees, and the corporate excise tax, is inelastic — that is, tax collections increase much less than total personal income in the state as the economy expands. There is little evidence to indicate that poor management, waste, or fraud contributes significantly to government expenditures; therefore, difficult political decisions cannot be avoided in the years ahead. The decision may take the form of continued cutbacks in government employment, consumption tax rates unrivaled elsewhere in the United States, or radical changes in the types of taxes levied. Which course is chosen will directly affect the level of future activity in the government sector.

Outlook for the 80's

Despite the present uncertainties, CBER forecasters are optimistic about the decade of the 1980's. Tennessee's basic economic strengths will continue to be an advantage for carrying out many kinds of activities. There is sufficient diversity in the state economy to maintain overall momentum, even if some of the uncertainties noted above prove to have negative effects. In every sector, employment and income should increase steadily, though at a slow pace (around 1986).

The trade and services sectors, after the cutbacks in the current recession, should respond to the decade's income and population growth and continue their long-term trend toward a larger portion of the state's gross product and employment. Employment in both sectors will grow between 2.0 to 3.0 percent per year in the last half of the decade, well above most other sectors (see Figure 2). FIRE, after a downturn in 1985 and 1986, makes a strong rebound by 1987 in both employment and output. Above-average job growth in this sector is sustained throughout the last half of the decade. The construction sector, following a small decline in 1986, grows at annual rates of nearly 3.0 percent.

Sectors with slower overall growth rates over the long term include TCPU, government, and manufacturing. Though manufacturing is expected to gain large numbers of jobs each year of the forecast, growth rates appear low due to the large manufacturing base. This forecast is based on the assumption that there will be no legislative changes in taxes; thus, the forecast for growth in the government sector is constrained by the expected decline in real revenues under the present structure.

The short-run forecast for manufacturing may conveniently be subdivided into forecasts for 1982 and 1983-1985.

1982 Outlook

Prudently stated, 1982 is not expected to be a banner year for output, employment, and wages in Tennessee manufacturing (see Table 1, p. 18). The output of durable goods should be affected most severely in 1982, falling 0.81 percent. Nondurable goods, however, should register positive but mild growth, 0.52 percent. The downturn in durable goods output will be led by (greater than one percentage point) reductions in the nonelectrical machinery, electrical machinery, and fabricated metals industries. Significant contributors to the mild output growth in nondurable goods in 1982 will be the apparel, textiles, and food industries. These industries are forecast to register output growth in excess of 1.5 percent.

Employment growth in Tennessee manufacturing for 1982 will mirror output growth. Total manufacturing employment will grow in 1982 from 512.5 thousand to 512.9 thousand workers, an increase of 0.08 percent. Sluggish manufacturing employment growth for 1982 is due primarily to the poor employment outlook in durable goods: fabricated metals, furniture and fixtures, and transportation equipment. The brighter side of the 1982 manufacturing employment picture comes from the nondurables industries, where all sectors except chemicals and apparel are expected to register employment growth.

Manufacturing wages will increase in 1982 from an average of $15,142 to $16,438. This represents a nominal gain of 8.56 percent. However, after the effects of inflation, real manufacturing wages are expected to fall slightly in 1982. Unlike manufacturing output and employment, the 1982 outlook for wages is better on average in the durables than nondurables industries. While real wages are expected to fall an average of 0.19 percent in durables industries in 1982, the average real wage decrease in nondurable goods industries will be 0.76 percent.

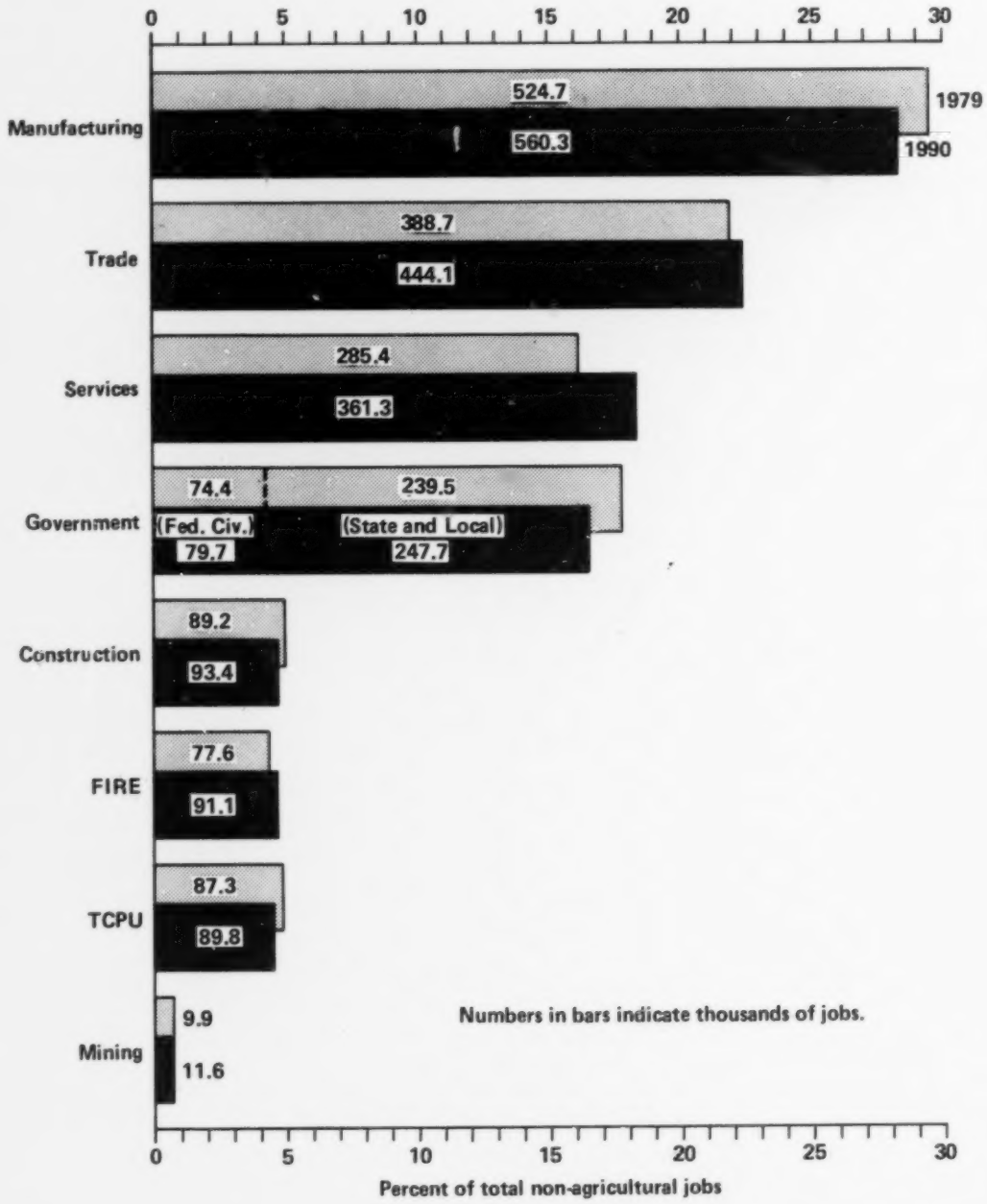
The manufacturing output, employment, and wage outlook for the 1983-1985 period is expected to be significantly brighter than for 1982. Manufacturing output, employment, and wages are forecast to rebound significantly from the 1982 downturn (see Figure 3).

Manufacturing output growth in the 1983-1985 period will be led by rapid growth in the transportation equipment and lumber and wood products industries. The growth in transportation equipment output will be aided by the opening of a large Nissan truck plant in late 1983. Employment growth in the transportation equipment sector will lead the anticipated employment growth in Tennessee manufacturing during the 1983-1985 period. Wage gains in manufacturing during the 1983-1985 period should be sufficient to result in real wage increases. For this period, real wage gains are forecast to peak at 2.23 percent in 1985.

Manufacturing output, employ-

FIGURE 2

TENNESSEE NONAGRICULTURAL JOB STRUCTURE AND JOB GROWTH, 1979 AND 1990



SOURCE: Tennessee Econometric Model, Historical data and January 1982 solution.

ment, and wages are all forecast to grow at moderate rates for the 1986-1990 period. Underlying this positive long-run outlook for manufacturing in Tennessee are several factors, principal among which are higher-than-average productivity, above-average population growth, and adequate supplies of relatively low-cost factors of production.

Trade and Services

Over the past decade, employment growth in both trade and services has exceeded that of every other sector except federal government. Traditionally, these two sectors, both nationally and in Tennessee, have been considered "recession-resistant." Although their growth rates since 1970 have followed the same roller coaster pattern as other sectors, the services sector's employment levels increased every year during the 1970's. Furthermore, trade never experienced less than a 1 percent decline.

This behavior during the 1970's decade will be altered during 1982. The effect of a recent unusual softness in trade and services, coupled with the decline in the government sector and the volatility of Tennessee's traditionally recession-sensitive manufacturing and construction sectors, had brought record levels of unemployment to Tennessee by the end of 1981. Despite the boost in 1982 that the eastern part of the state is expected to receive from the World's Fair — a boost that will benefit primarily trade and services — these two sectors, and the state's economy as a whole, will not see robust growth in 1982. In real terms, the trade sector's growth of 1.07 percent is the highest achieved by any output sector except mining and agriculture. Retail sales should experience more than 3 percent real growth after adjusting for inflation. Despite the turnaround in trade output, trade employment will continue to decline slightly.

The services sector will likewise do better than most other sectors in 1982; nonetheless, its growth will be modest. Real output for services will be up 0.73 percent, more than total gross state product. Employment will continue to increase, but at a slower rate than in 1981. Despite erosion in the stability of these two sectors, they still fare somewhat better in the current recession than the traditionally volatile sectors.

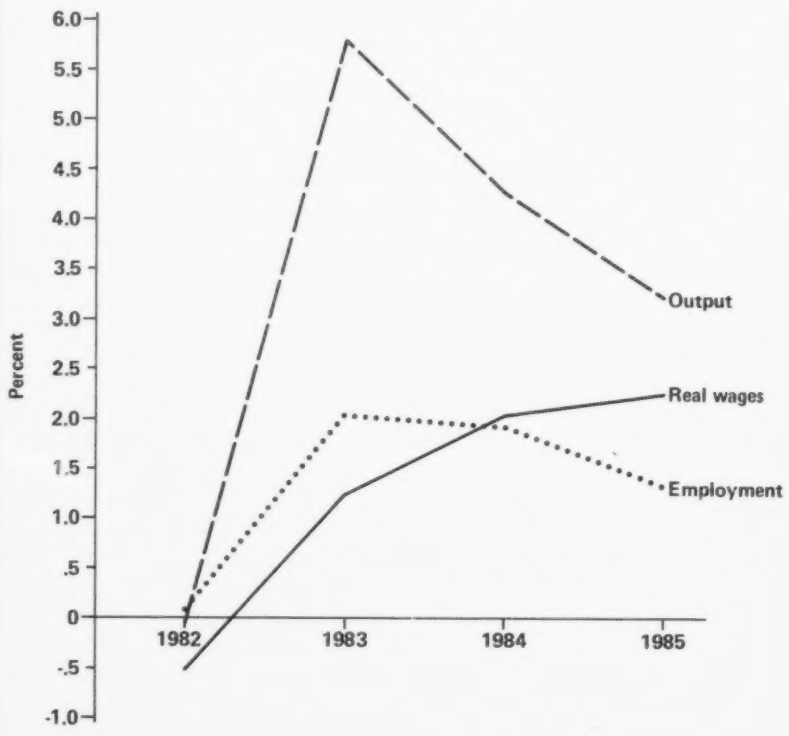
Through 1984, both trade and services will experience increasingly robust rates of growth. Responding to somewhat lower interest rates and higher employment and real income, retail sales rebound to a peak growth rate of 4.59 percent in 1984, adjusted for inflation (see Table 1, p. 18). One important component of trade growth involves auto stock replacement. By the end of 1982, the improved economic outlook, combined with replacement of depreciating automobiles should create a period of exceptional sales in 1983 and 1984. Sales increases of 6.6 and 6.2 percent in those two years, adjusted for inflation, are forecast. By 1984, employment in the trade sector will surpass peak employment levels in the 1970's.

After the peak economic activity in 1984, growth in trade and services, along with other sectors, will slow in 1985 and will reach a cyclical low during 1986 which is not expected to have the serious dimensions of the present recession. With employment growth of 1.54 and 1.45 percent, respectively, the trade and services sectors will sustain higher growth in the 1986 downturn than most other sectors, as they have traditionally.

Beyond 1986, these two sectors grow at similar rates, with annual average employment growth between 2.0 and 3.0 percent. These rates, well above those for employment in most other sectors, are a continuation of the national and state secular trend and

FIGURE 3

PERCENT CHANGE IN MANUFACTURING REAL OUTPUT, EMPLOYMENT, AND REAL WAGES, 1982-1985



SOURCE: Tennessee Econometric Model, January 1982 solution.

make Tennessee's strength in these two sectors more similar to the United States economy. By 1990, trade will account for 22.4 percent of Tennessee employment, and services, 18.3 percent. This combined total of 40.7 compares to 38.5 percent in 1981 and 33.3 percent in 1970.

Finance, Insurance, and Real Estate

Following the usual practice in aggregate economic analysis, finance, insurance, and real estate (FIRE) are grouped into one sector for purposes of forecasting output, employment, and wages. In addition, the model forecasts certain balance sheet items for commercial banks and savings and loan institutions. This section summarizes the forecasts for the FIRE sector and gives the outlook for commercial banks.

The most recent period of recession and recovery in Tennessee (1973-1976) provides a convenient basis for comparison with the 1981-1983 period of recession and recovery. During this period, real growth rates in FIRE's output followed the directions of the state's economy but fluctuated less. Furthermore, during the 1974-1975 recession, the FIRE sector's employment growth was stronger and more stable than other sectors, whereas its wages were more volatile.

In general, the forecast for 1981-1983 does not parallel the experience in 1973-1976. Adjusting for inflation by calculating GSP in 1972 dollars shows that the 1982 growth in real output will be approximately one-half of a percent. FIRE real output actually declined in 1981 (state real GSP rose) and will lag behind state GSP in 1983. Thus, unlike the case in 1973-1976, FIRE real output will not always follow the direction of state economic activity and will lag behind Tennessee's recovery pace.

Employment in the FIRE sector will be much more volatile in the short term than it was during 1973 through 1976. For instance, while Tennessee employment (measured in persons) remained constant in 1981, FIRE employment (measured in jobs) declined by 2.55 percent. Further, the FIRE sector employment increases in 1982 and 1983 are each significantly larger than the comparable nonagricultural jobs forecasts. This sector seems to magnify whatever employment changes occur in the state economy as a whole.

One partial explanation for this sector's output performance can be seen by examining FIRE output per employee, that is, productivity. FIRE productivity will be stagnating in the short term. In fact, output per employee actually declined in 1981. This stagnation means that employment changes, rather than employment *and* productivity changes, will almost solely determine output changes. If productivity were to rise by even a moderate amount in 1981 and 1983, the performance of FIRE's output would more closely approximate that of the total. Thus, we see that the poor productivity performance of the FIRE sector's employees will contribute to the poor performance of the sector's output when compared with the total activity.

Virtually the only similarity between 1981 through 1983 and 1973 through 1976 occurs in real wages. In 1973-1976, FIRE real wages were more flexible than those of the entire state. In 1981, FIRE wages grew over three times faster than average state wages. This sector's growth rate in wages will drop dramatically to almost equal the growth rate in Tennessee wages for 1982. Then, they will rebound to a growth rate of 2.2 percent compared to state wages, which will increase by 1.4 percent.

Commercial Banks

The period 1981-1983 will find the total deposits of commercial banks rising by a sluggish 6.6 percent in the first year, 8.1 percent in the second year, and a more vigorous 10.6 percent in the third. These rates are each 1.5 to 2.0 percentage points higher than those in 1974-1976, perhaps in part because of higher inflation rates.

The predicted performance of the loan-to-deposit ratio should encourage commercial banks. This ratio will climb steadily from 67.5 percent in 1981 to 68.3 percent in 1983. This increased loan demand will be due, in part, to increased auto sales and lower interest rates. However, these lower interest rates will reduce the average yield on loans by over 2 percentage points from 15.7 percent to 13.6 percent. This may be offset slightly by the modest cost savings realized from All-Savers Certificates.

Although FIRE real output will not parallel total activity in the short term, and its growth rates will lag behind those of gross state product, the reverse will be true in the long term. Both real GSP and FIRE real output growth rates will decline from 1984 through 1986, rebound in 1987, and then stay at roughly their 1987 levels through 1990. The jump from 1986 to 1987 will be much larger in the FIRE sector than in the total, however. In contrast to 1981-1983, the growth in FIRE's real output will be around 3.6 percent per year over 1984-1990, while the GSP growth will average roughly 3.0 percent per year.

The cause of this reversal in relative growth may be found by examining both predicted employment and productivity patterns. This sector's employment growth will surpass Tennessee's employment growth in every year from 1984 through 1990. These above-average employment growth rates certainly contribute to the sector's vigorous output growth. However, a more significant factor may be the projected striking improvement in the productivity of the FIRE sector's employees in the long term. During 1981 through 1983, output per employee will decline slightly. Productivity is forecast to rise by nearly 1.5 percent per year in the long term, however.

Similarity will characterize the patterns of state and FIRE real wages over the long term. FIRE wages will rise and fall in step with Tennessee wages, although this sector's growth rate will usually surpass the state's. The excess will be slight, however, as evidenced by a predicted Tennessee growth rate of around 2.3 percent per year and a FIRE average growth of about 2.4 percent.

The simplest characterization of the long-term picture for commercial banks is that short-term trends will continue. Interest rates will plunge significantly from 1983 to 1984, but will then drift slowly downward over the remainder of the decade. Real personal incomes will rise steadily, thus fostering increased demand for goods and services. Consequently, average annual deposit growth, which equalled 8.8 percent in 1974-1976 and will reach 9.3 percent in 1981-1983, will rise to approximately 10.2 percent in the long term. This high rate will be caused primarily by rapid growth in time deposits. Demand deposits will grow steadily but slowly. Further, the loan-to-deposit ratio will continue to climb to around 70 percent by 1990. In addition, the average yield on loans will follow the downward path of interest rates by descending roughly 1.5 percentage points to below 11.0 percent. This decline will be much more gradual than the fall of over 2.0 percentage points to be seen during 1981 through 1983.

Transportation, Communications, and Public Utilities

The transportation, communications, and public utilities (TCPU) sector comprises a small but diverse number of firms, many of whose operating environments are influenced by various regulatory agencies.

These agencies have powers that to some extent control entry and exit, the level of rates that can be charged, control of operating expenses, approval of mergers, level of operation, and many other aspects of business management. Historically, this regulatory environment has served somewhat to insulate this sector from the ups and downs of the business cycle, making forecasting relatively easy. However, within the last three years new legislation has been passed deregulating some aspects of the airline, trucking, and railroad industries. New regulatory initiatives are underway in the communications sector. All of these efforts will have an important impact on this sector, but it is difficult to determine what form this will take.

The TCPU sector is expected to recover somewhat slowly from the current downturn in 1982. Employment is forecast to continue declining, but at a slower rate, while nominal dollar output rebounds at a 12.07 percent annual rate. However, increases in output do not return in the long-run growth path until 1984. During the forecast period, employment is expected to grow at an annual compound rate of 1.0 percent — one-third the rate achieved during the 1970's. Employment is not forecast to return to the 1979 peak of 87,300 until 1989.

During the 1980's, nominal output is forecast to grow somewhat slower than the long-term trend, but at a somewhat higher annual compound rate than gross state product. This slowdown is primarily a result of slower anticipated growth of the state's economy during the next decade. Slow employment growth can be explained by the capital-intensive nature of the industries in TCPU and the likelihood of significant productvity improvements, especially in the transportation and communications groups. The main unknown factor in this forecast is the long-run effect of deregulation on the transportation and communications sectors. Depending on price elasticities (normally considered relatively inelastic in these industries), deregulation could lead to a larger long-run expansion of output and employment than is forecast here.

Construction

Tennessee construction output is determined by GSP and long-term interest rates.

Several factors combined in 1981 to push interest rates very high and will combine again in 1982 to support them at only slightly lower levels. First, a reduced rate of growth of the money supply, which tends to raise interest rates, will inhibit private spending for, among other things, residential construction. Second, President Reagan's projected huge budget deficits are expected to fuel inflationary expectations, which are often manifested in higher interest rates. Therefore, interest rates will be nearly as high in 1982 as they were in the latter part of 1981. However, we do expect that rates will dip somewhat by either late 1982 or early 1983. Furthermore, the 1980-1982 recession's effects on economic activity are expected to continue into 1982, with the most anemic recovery ever seen. Consequently, Tennessee's economic activity is not likely to increase significantly until late 1982 or early to mid-1983.

The expected performances of both the Tennessee economy and interest rates are reflected in the forecasts for the years 1981-1983. State GSP crept up in 1981, will rise slowly in 1982, but will rebound dramatically in 1983, with a jump of 3.89 percent. Not surprisingly, the recovery in the state's construction industry will wait until 1983 also. 1981 suffered a decline in real construction output of 3.01 percent, and 1982's real output will also drop. During 1983, real construction output will leap by 9.01 percent to a level of over $865 million. Despite this growth, the 1983 level of output will still fall short of real construction output in 1971.

Construction employment in 1981 mirrored and exaggerated the predicted performance of construction output. 1981's employment fell by 8.6 percent and the number of construction workers employed in 1982 will drop farther (see Table 1, p. 18). The plight of the state's construction industry by 1982 can be seen clearly through the realization that construction employment in 1982 will be at its lowest level since 1970. However, employment will rise 7.9 percent in 1983 as interest rates decline and funds for building new residences proliferate.

While the forecasts for output and employment contain gloomy elements, the expected performance of construction's real wages presents an encouraging prospect. From 1981 through 1983, average construction real wages will exceed average wages for all sectors.

The period 1984 through 1990 reflects the usual situation of construction output responding to both

Tennessee overall economic activity and long-term interest rates. State GSP growth will reach a peak rate in 1984, slow for two years, and then follow a strong upward path for the remainder of the decade. In addition, we expect that interest rates in 1984 will continue the significant plunge which they will begin in 1983 and then drift slowly downward through 1990. The combination of a precipitous decline in interest rates, peak growth in state economic activity, and pent-up demand for housing will induce a growth in construction output during 1984 of around 9.0 percent. Afterwards, output will follow the direction of Tennessee activity for two years and then rise to a range of growth rates around 3.7 percent per year in the final three years. Despite this healthy growth, it will be 1985 before real construction output will exceed 1973's real output level.

Whereas the performance of construction employment will be mixed during 1984-1990, real wages for this sector will move continually and strongly upward. Responding to those factors which will generate high output in 1984, employment will first grow at a vigorous 9.5 percent (see Table 1, p. 18). Next, the growth rates will fall until reaching negative rates (a decline in employment) in 1986, jump quickly to relatively high growth, and then level off at around 2.9 percent growth per year in the final two years. In contrast to employment, the real wages of construction employees will stay higher than statewide average wages and will exhibit larger rates of growth in every year during 1984-1990. These two characteristics will continue the performance of real wages during 1981 through 1983.

Energy

In most sectors of the Tennessee economy, changes occur slowly and can, at least to some extent, be anticipated. In both these senses the energy sector has proved quantitatively and qualitatively different over the past decade as consumption patterns of all primary energy sources in Tennessee have undergone substantial shifts.

Energy consumption, which had previously been thought to be insensitive to price changes, has fallen significantly or slowed substantially in growth for every primary energy commodity. As a result of this newly found sensitivity of consumption to price changes, the short-run forecast for energy consumption reflects only small increases. In 1982, electricity consumption will grow by only 0.43 percent, due primarily to slow economic growth and the adjustment made by consumers to recent electricity price increases (see Table 1, p. 18). Electricity consumption is expected to grow in the neighborhood of 1.5 to 2.0 percent during the 1983-1985 period, with residential electricity consumption growing more slowly than consumption by commercial and industrial users. Natural gas consumption in Tennessee will fall during the 1982-1985 period. Consumption reductions will be on the order of 1.5 to 2.0 percent in the short run. Coal consumption in Tennessee is expected to grow in the 1982-1985 period by around 1.0 percent annually, with the exception of 1983, in which there will be a mild downturn in consumption. Gasoline consumption will remain approximately at its 1982 level through 1984, at which time consumption will increase by 1.5 percent. Fuel oil consumption will grow between 1.0 and 2.0 percent annually during the 1982-1985 period.

Energy prices have played, and will continue to play, an important role in determining energy consumption. In the 1982-1985 period electricity prices are expected to rise rapidly and to increase by 9.0 to 10.5 percent annually through 1985, though the increase will be sensitive to both the TVA building plan and the real interest rate (see Figure 4). In addition to the conservation-inducing effect of the level of electricity prices, the structure of rates will change to induce further consumption reduction. Natural gas prices are expected to rise rapidly through 1985 as prices are deregulated. Because of the relative abundance of coal and excess capacity in coal production, coal price increases should not be as high as for other energy sources through 1985. Gasoline price increases, which have experienced large jumps in 1974 and 1979, are expected to moderate through 1985. This reflects the current world oil glut, more stable sources of imported oil, and increased domestic drilling activity which accompanied price deregulation.

It is now clear that long-run economic growth is less susceptible to energy price increases than had been thought during the 1970's. As energy prices increase, substitution will occur both between alternative energy sources and between energy and other factors of production. As a result, energy consumption is expected to grow by only about 2.0 percent annually through 1990. This is significantly lower than the historic consumption growth. Energy prices in the long run will be governed by the laws of supply and demand. Slower growth in energy consumption will have a moderating effect on long-run energy prices. On the supply side, prices will be driven by the additions, or lack of additions, to reserves of primary energy stocks and by changes in technology.

Government

The recent slowdown in state and local tax collections and anticipated cutbacks in federal transfers lead to a forecast of slow government output and employment increases in the 1980's. Government sector nominal dollar output is expected to expand at an 11.1 percent annual compound rate over the next nine years compared to an 11.6 percent annual rate during the 1970's. Government employment should grow very slowly during the 1980's, achieving only an 0.8 percent annual rate.

During the past decade, state and local government expenditures grew by 180 percent and employment by 30 percent. However, this growth was not continuous, but came in spurts. State tax collections, the largest source of tax revenue for state and local governments, grew most rapidly during fiscal 1968, 1972, and 1977 because of substantial tax increases.

Each time the real spending power

of state tax revenues declined appreciably under the impact of national recession and continued high rates of inflation, the legislature had to resort to tax increases to restore the real value of the state tax dollar. Despite the relatively high rates of growth experienced by the Tennessee economy, especially over the first half of the period, this growth contributed very little to the state tax revenue picture.

State Tax Increases

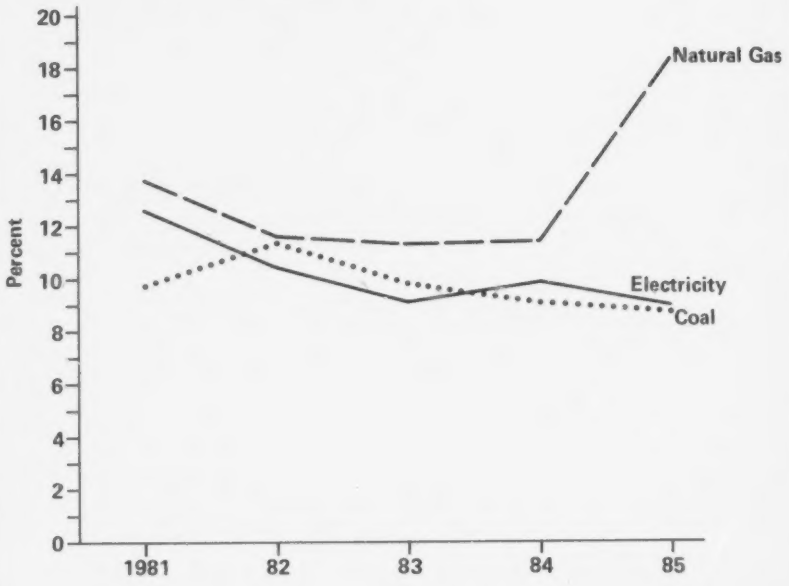
As in prior periods, the recession of 1980 triggered a need for state tax increases. In 1981, the Legislature enacted a 2¢ increase in the gasoline tax and other increases for truck licensing. Tax revenues, which grew only 4.5 percent in nominal dollars between fiscal 1980 and 1981, are expected to increase 11 percent this year. Gasoline taxes should grow by 33.0 percent and motor vehicle taxes by 17.0 percent. Next year, however, the overall rates of increase should decline to 7.0 percent, if there are no new tax increases.

In contrast to past increases, the tax increases enacted in 1981 primarily benefit the Highway Fund rather than the General Fund. General Fund taxes are expected to continue to grow slowly this year and next. Between 1979 and 1981 the real value of state tax collections declined by 8.0 percent. This trend is reversed slightly in fiscal 1982 because of the tax increases, but is expected to continue in fiscal 1983. Next fiscal year it is expected that the real value of state tax revenues will be the same as it was four years ago.

The anticipated slowdown in state and local tax collections may lead to layoffs and hiring freezes at the state and local levels during this year. In addition, TVA is considering shutting down construction of two reactor projects at Hartsville and one at Yellow Creek in Mississippi near the Tennessee border. This will lead to a loss of 4,000 government jobs during the 1982-1985 period and an additional 500 jobs during 1986-1990. TVA construction employment is already down significantly from its peak in 1980 because of the decision last year to delay completion of several nuclear projects in the state. If these additional layoffs occur during the decade, total government employment should decline through 1986 and not begin to grow again until 1987.

FIGURE 4

PERCENT RATE OF CHANGE IN PRICE OF ENERGY BY TYPE, 1981-85



SOURCE: Tennessee Econometric Model, January 1982 solution.

Because these projections assume no future tax increases at the state level and no expansion of local government taxing authority, the growth of total tax collections at the state and local levels is expected to be lower during the coming decade than during the last. Since inflation is expected to persist, although at lower rates, the real value of state and local tax dollars is forecast to decline. By 1990, each dollar of state tax revenue is expected to be worth 92¢ in purchasing power and each local dollar, 87¢. Besides the erosion of state-local tax bases because of inflation, the economic growth of the state is expected to be somewhat slower during the 1980's than it was during the 1970's. Looking at total state tax collections adjusted for rate and base definition changes occurring since 1967, one can get a measure of the impact of economic growth on the state's tax collections that are purged of the effects of inflation and periodic tax increases. During the 1970's, this grew by 18.5 percent, indicating that the growth of the state's economy contributed to some extent to the long-run increase in state tax revenues, but this trend is not anticipated to continue in the 1980's.

Analyzing projected trends in state tax collections leads to a notable conclusion. When projected collections are adjusted to remove the effects of tax increases and inflation, their trend declines over the long term. During this forecast period the state's economy is expected to grow in real terms. Hence, without periodic tax increases in the future, Tennessee's tax system is forecast to remain unresponsive to this growth, and state and local government will receive ever smaller shares of the total annual output available for consumption and investment. ■

Of Current Interest

To Data Users:

Now available from the Center for Business and Economic Research are two publications of interest to data users —— **The Tennessee Statistical Abstract** and the newly published **Tennessee Geography: The 1980 Census Areas.**

Tennessee Statistical Abstract, 1980. Patricia Postma, editor. Over 700 pages in 19 chapters of tabular data, maps and diagrams. Includes both current and historical data on the economic, social and political structure of the state with comparative data on the Southeastern states and the nation. Triennial. 720 pp.

Tennessee Geography: The 1980 Census Areas, 1982. Prepared by Patricia D. Postma. Provides a comprehensive discussion of the geographic concepts and tools related to the **1980 Census of Population and Housing** that apply to Tennessee and its subdivisions. Contains the most recent Census data available. Data are provided for both political units and statistical units. 34 pp.

For further information about these publications, contact: Center for Business and Economic Research, Suite 100, Glocker Business Building, The University of Tennessee, Knoxville, Tennessee 37996–4170. (615)974-5441.

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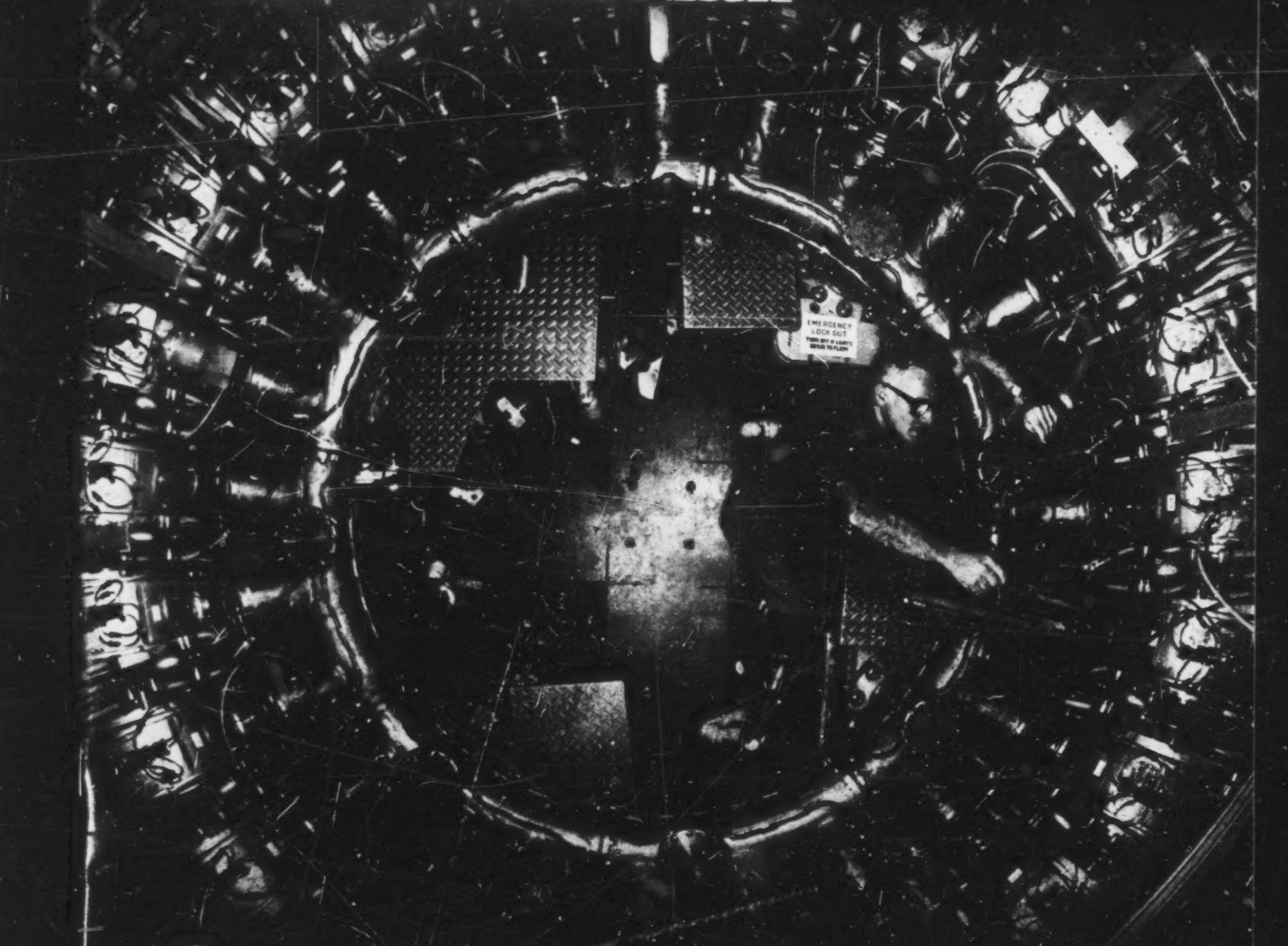
TECHNOLOGY IN TENNESSEE

THE UNIVERSITY OF TENNESSEE



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SUMMER 1982 VOLUME 18, NUMBER 1

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THE UNIVERSITY OF TENNESSEE, KNOXVILLE

TECHNOLOGY IN TENNESSEE

4

The Technology Corridor: Building on our Assets

Lamar Alexander, Governor of the State of Tennessee

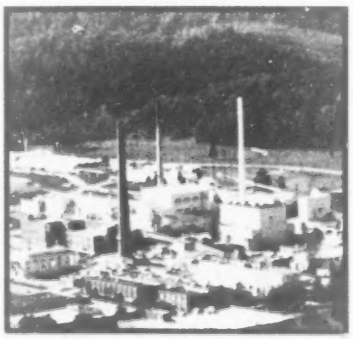
John L. Parish, Tennessee Commissioner of Economic and Community Development

James A. Haslem, II, Chairman of the Technology Corridor Task Force

11

Federally Funded R & D: New Opportunities in Tennessee

Herman Postma, Director of Oak Ridge National Laboratory



17

Developing a High-Tech Complex Through Small Company Formations

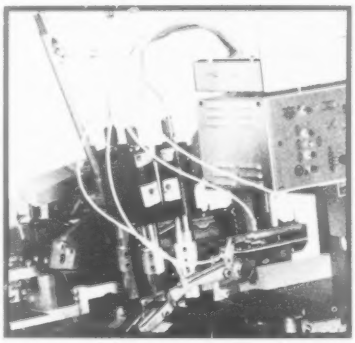
Albert Shapero, Albert Davis Professor of Free Enterprise at the Ohio State University, Columbus

21

Applications of Modern Technology: The Textile Industry; The Apparel Industry

Hugh G. Neil, Jr., President of Special Instruments Laboratory

Sam H. Pearsall, Jr., Vice President of Cutters Exchange



27

Technology and Automation: the Nissan Experience

Ed Miller, President of Oak Ridge Facility and Manufacturing Automation

Ed. Note: For the records of librarians, there was no Spring issue of the Survey *printed in 1982; therefore, Volume 17 will have only 3 numbers.*

Cover: Elmo Bumpy Torus, an experimental machine designed and built by Oak Ridge National Laboratory to advance knowledge about deriving limitless energy from atomic fusion. (Courtesy TVA.)

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CONSULTING EDITORS' COMMENTS

In this issue of the **Survey**, the theme of which is "Technology in Tennessee," our authors focus on both actual technological benefits of the past and potentially greater benefits of the future.

In the lead article, Lamar Alexander, Governor of the State of Tennessee, along with John L. Parish, Commissioner of Economic and Community Development, and James A. Haslam, II, Chairman of the Technology Corridor Task Force, review the potential benefits of a "Technology Corridor," a development specially planned to attract high-technology firms to Tennessee. Next, Herman Postma, Director of Oak Ridge National Laboratory, discusses the role of federally funded research and development in Tennessee – both in terms of its direct contribution and its ability to support the research efforts of private firms and to spark the birth of new high technology firms. Albert Shapero, the Albert Davis Professor of Free Enterprise at the Ohio State University, discusses the advantages of a "home-grown" strategy for high technology development, suggesting various ways to encourage entrepreneurs to begin new high-technology firms.

These first three articles point out that technology-based economic development feeds and grows on a base of specialized capability that has developed over the years. Two of our authors discuss the particular technological contributions which Tennessee firms have made and continue to make in the state's older industries – textiles and apparel. First, Hugh G. Neil, Jr., President of Special Instruments Laboratories, Inc. (Spinlab) in Knoxville, discusses the contributions to fiber technology which facilitated both improved breeding and better utilization of cotton through fiber science. Next, Sam H. Pearsall, Jr., Vice President of Cutters Exchange and Vice President of Cutters Electronics, reviews the application of modern technology to the apparel industry.

In our closing article, Ed Miller, President of Oak Ridge Facility and Manufacturing Automation, discusses the development and potential of automated control systems in general, and the specific application of this exciting technology at the new plant of Nissan in Middle Tennessee.

Norbert Ackerman,

H. Dudley Dewhirst,

and Patricia D. Postma,
Consulting Editors

Norbert J. Ackerman *is President of Technology for Energy Corporation (TEC), a Knoxville firm providing specialized engineering services and instrumentation for the energy industry. Prior to establishing TEC in 1976, Dr. Ackerman was employed in the Instrumentation and Controls Division of Oak Ridge National Laboratory. He has been a member of the Governor's Task Force to study the feasibility of The Technology Corridor in Tennessee.*

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Patricia D. Postma *is a regional economist and a Research Assistant Professor on the staff of the Center for Business and Economic Research, College of Business Administration, The University of Tennessee, Knoxville.*

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The Technology Corridor: BUILDING ON OUR ASSETS

Lamar Alexander, John L. Parish, James A. Haslam, II

In the fall of 1981, Lamar Alexander, Governor of the State of Tennessee, appointed a task force to assess the feasibility of establishing a "Technology Corridor," a development specially planned and managed to support and attract new and expanding high-technology industry. This article outlines the findings and conclusions of the task force and presents Tennessee's prospects for attracting and supporting a share of this dynamic sector of American business.

The task force concluded that Tennessee has great potential for accelerated economic growth utilizing the Technology Corridor concept as a means of attracting and supporting high-technology industry. To realize this potential, however, the state will need to take steps to strengthen its institutions to better utilize its technological strengths and resources, and to aggressively market Tennessee as a state that is particularly responsive to the special needs of both new and well established high-technology firms.

Almost any discussion in economic development circles today eventually leads to the topic of "high technology." Although this universally appealing phrase continues to elude a specific definition, most agree that high-technology industry is that which requires extensive scientific and/or advanced engineering support for continuing development of new products, and that high-technology enterprises are commonly associated with both rapid *and* long-term growth of the firms involved as well as the areas in which they are located. However, contrary to a popular misconception, high-technology companies are not staffed only by scientists and engineers, but include many people with high school, technical, or community college education.

Given today's economic climate, it is not difficult to understand why the competition for the location of high-technology firms is so fierce. Each year more than 3,000 communities recruit the 200 or so firms that are moving or expanding to new locations. These firms are sought because they are thought to be nonpolluting, to pay high wages, and to place minimal demands on local governments for utilities and social services. They also have a tendency to "spin off" new firms and to attract additional related industry.

Economic Impacts

There is also a significant difference in the economic impact of high-technology firms relative to other industry. Table 1 shows the substantially higher impact from three selected technology-based firms, compared to the average manufacturing firm in Tennessee. Two of these companies are "spinoffs" established by former employees of Oak Ridge National Laboratory and The University of Tennessee, Knoxville. The third is a branch plant established by a major high-technology firm headquartered in the West. If Tennessee's goal is to raise family incomes, the wage and salary statistics in Table 1 point toward two compatible strategies for accomplishing that goal – the recruitment of high-technology businesses *and* the support of the development of new ones.

Aggressiveness is the byword in the recruitment of high-technology industry. Government officials in states where concentrations of high-technology industry already exist have taken measures to encourage additional development. For example, despite

the budget pressures affecting all states just now, North Carolina is investing $25 million for the development of integrated circuitry manufacturing in that state. It is planned that several million more will be invested for biotechnology research and development. California, recognizing that one out of four new jobs is created by high technology, is giving additional tax incentives for the location of this type of industry. Other states are pursuing similar initiatives.

State Resources

Many universities have established technology/industrial parks. Princeton, Purdue, and Stanford are some of the better-known success stories. Other institutions such as the University of Utah, Georgia Tech, and Cornell are becoming strong contenders for the high-technology market, and several states are offering complete training programs to meet the specific needs of particular firms. Given these examples, what are the prospects for Tennessee?

Tennessee is not typically viewed as a haven for high-technology business and industry. Yet, there are substantial concentrations of public and private high-technology activity located throughout the state, with a most significant concentration in and around Oak Ridge.

This dense concentration of engineers, scientists, and skilled technical workers was originally gathered to develop the atomic bomb, a war effort that made Oak Ridge known throughout the world. Peace permitted a shift of this vast bank of talent toward nonmilitary uses of the power of the atom and toward understanding the physical properties and impacts of these uses. Today, with the Oak Ridge federal facility and its several private spinoffs, with The University of Tennessee and TVA, East Tennessee has one of the world's largest concentrations of individuals with doctorates and the largest concentration of professional biologists.

Also in East Tennessee, at Knoxville, The University of Tennessee has grown to become a ranking university with several prominent centers of excellence in science and engineering. TVA, also headquartered in Knoxville, has become one of the nation's larger engineering design and construction organizations, with substantial expertise and research and development investments in energy technology.

The public expenditure represented in these three huge organizations – ORNL, UT-K, and TVA – has attracted private activity also. Several private firms have been successfully developed by former employees of Oak Ridge National Laboratory and The University of Tennessee, and a significant number of the nation's major corporations have established offices in the area, diversifying the state's economy and leading to a broader range of job opportunities for our youth as well as bringing in new people.

Tennessee's Prospects

Yet, when one considers the potential, Tennessee has not fully benefited from the opportunity presented by this massive federal, state, and private investment. It was with this in mind that a task force was appointed in October of 1981 to determine the feasibility of a development now described as the Tennessee Technology Corridor, in the general area of the Pellissippi Parkway between Oak Ridge and Interstates I-40 & 75 just west of Knoxville.

This task force has made an extensive study of several successful high-technology developments, including the Research Triangle Park near Raleigh-Durham, North Carolina; "Silicon Valley," in Santa Clara County, California; and "Route 128" near Boston, Massachusetts. Its members also reviewed the assets and liabilities of Tennessee and concluded that the

TABLE 1

COMPARATIVE ECONOMIC IMPACT: HIGH TECHNOLOGY VS. AVERAGE MANUFACTURING

(Selected 1981 Data)

Firms	Employees	Average Wage	Total Wages & Salaries	Facilities Cost
Mature hi-tech firm	400	$22,000	$8,800,000 +	$ 3,500,000
Early stage hi-tech firm	200	27,500	5,500,000	8,500,000
Recent hi-tech mover from outside	300	25,000	7,500,000	60,000,000
Average Tennessee manufacturing firm (1981)	90	15,400	1,386,000	- -

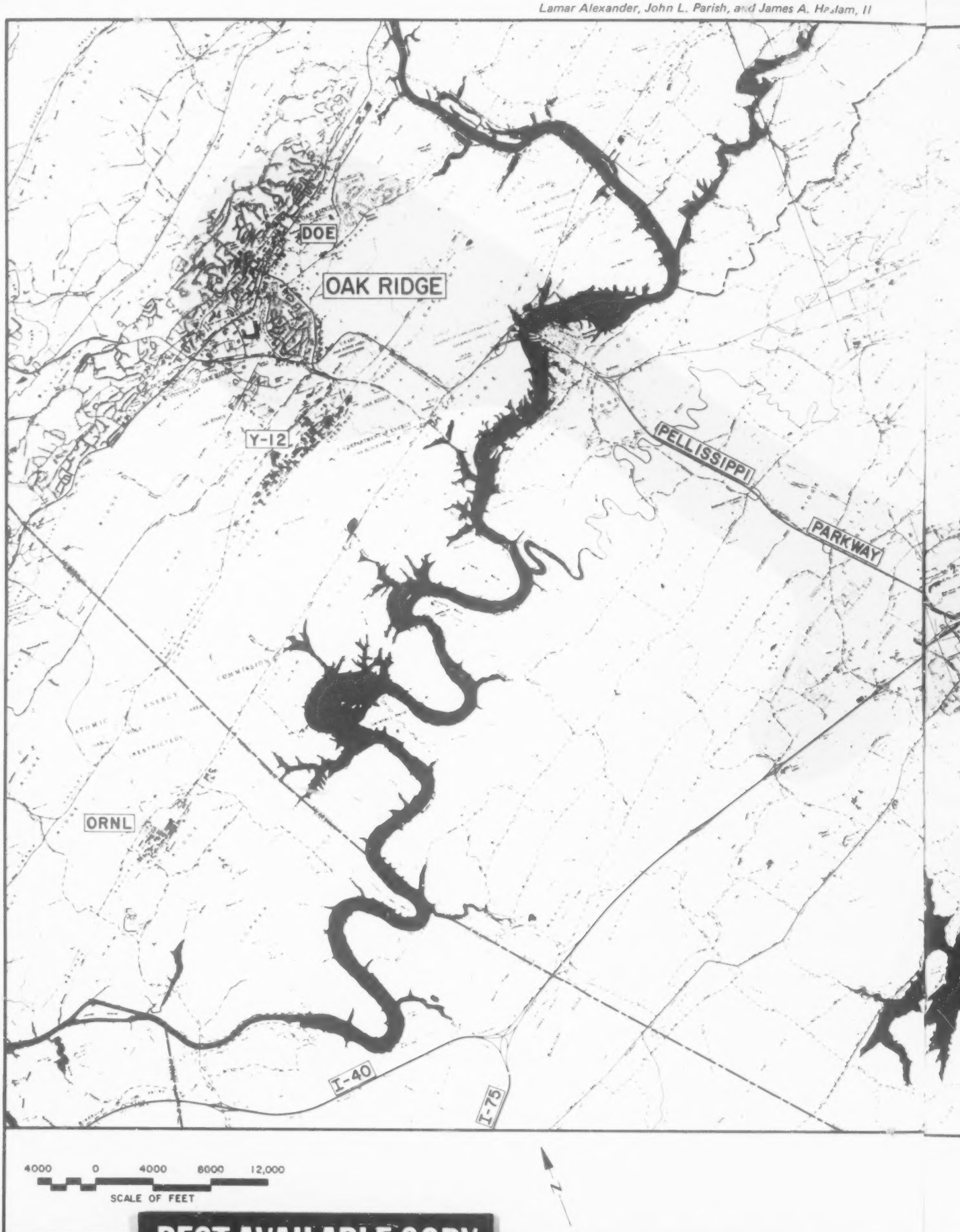
Source: Compiled from records of selected industries.

Lamar Alexander, *Governor of the State of Tennessee, believes that the growth of technology-related research in the state is critical for raising incomes and providing job opportunities for Tennesseans. He has appointed a task force of leaders in education, research, and manufacturing to assess whether state facilities already planned, with the extensive research activities existing at The University of Tennessee and Oak Ridge National Laboratory, can form the basis for future high-tech private sector development in the state. In this article the Governor "summarizes" the findings of his task force.*

John L. Parish *is Commissioner of the Tennessee Department of Economic and Community Development. He is President of Worth Sports Company/Lannom Manufacturing Company, Inc., is past chairman of the Tullahoma Regional Planning Commission, and has served on the Tullahoma Industrial Development Board since 1980.*

James A. Haslam, II, *President and Founder of Pilot Oil Corporation, is Chairman of the Governor's Technology Corridor Task Force. He is also a director and member of The Management Committee of the Knoxville International Energy Exposition, the organization responsible for the 1982 World's Fair.*

Dave Patterson, *in the Office of Planning and Budget, Tennessee Valley Authority, has served as a staff member to the Governor's Task Force on the Technology Corridor. He assisted in compiling information for this article.*



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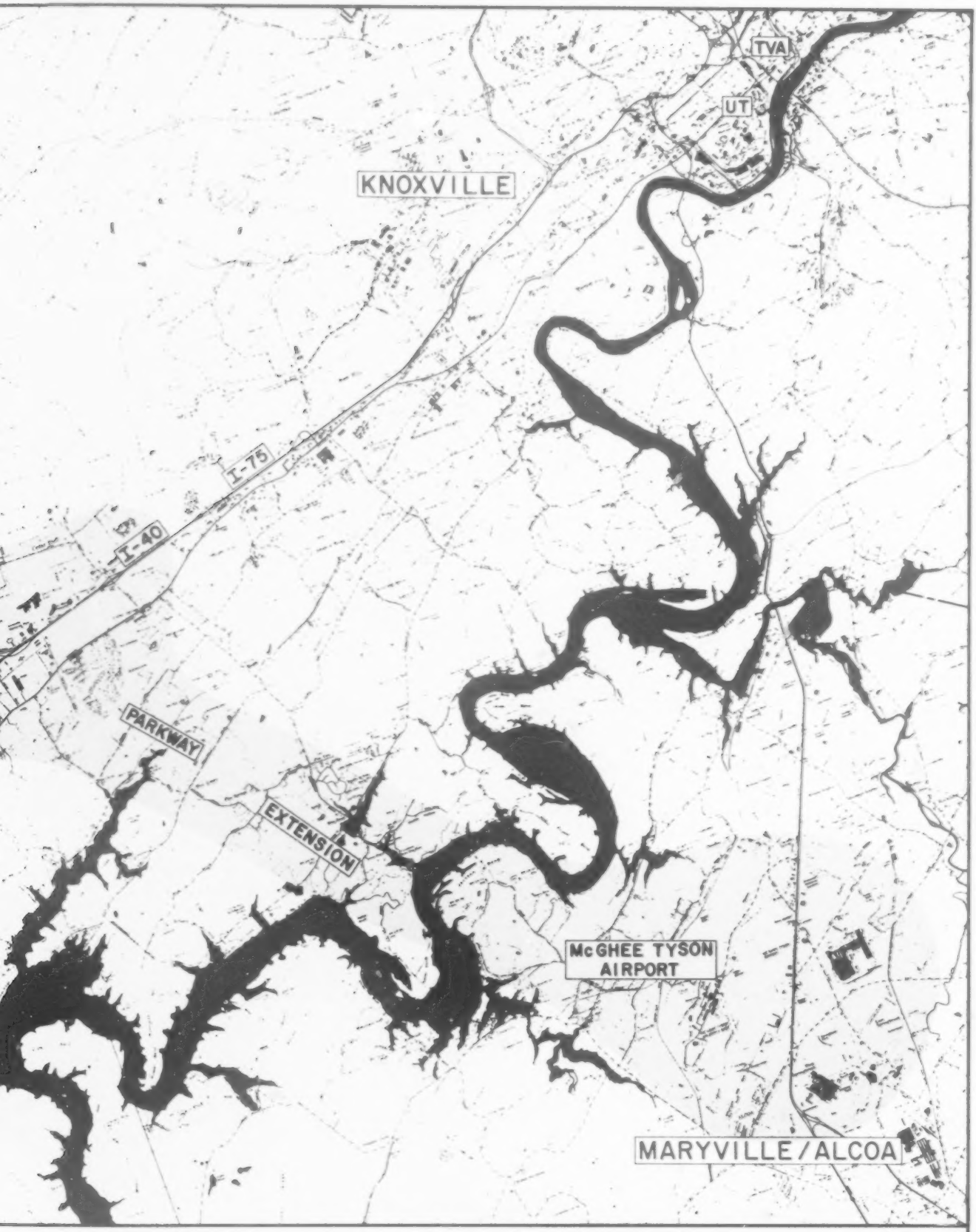


FIGURE 1 **TECHNOLOGY CORRIDOR CONCEPT MAP**

Knoxville/Oak Ridge area is particularly suited for "high technology" industrial development. Its relatively undeveloped, pastoral character, easy access to high-speed arterial highways and commercial air services, suitability for low-density, campus-like development, and proximity to the strong technological base already in place in the area, when matched with the other assets of Tennessee, should be appealing to organizations looking for a new site.

In addition to these attributes and other "quality-of-life" characteristics typically required by employees of high-technology firms, the area has institutions in place capable of responding to their research, management, and manpower training needs. In short, the Corridor has, or can have, all the physical and institutional resources necessary to be successfully marketed as an excellent location for high-technology industry.

Geographic Boundaries

Figure 1 illustrates the geographic area which the task force has defined as the Technology Corridor. Beginning within the city limits of Oak Ridge, the concept presently encompasses lands on each side of the Pellissippi Parkway extending for over 20 miles to lands near the McGhee Tyson Airport. In addition to those segments of the parkway not yet completed, the Corridor also includes lands adjacent to the segment of I-40/75 that intersects with the parkway and, for marketing purposes, any other lands in the general area that can meet the high-quality siting criteria generally demanded by high-technology firms.

This delineation of the corridor does not mean that all lands in this geographic area should be exclusively designated for, or are even suitable for, high-technology industry. A variety of land uses is both appropriate and necessary to support balanced economic growth. But the task force believes that this land base, when combined with the technical resources and enhanced manpower training capability of the area, will provide an attractive package that can be effectively marketed to national and international firms. It will also provide ideal sites on which local firms can get started or expand. In addition, the corridor should stimulate significant spin-off industry outside its immediate boundaries and throughout the state, a development which has occurred elsewhere with this sort of concentration. In other words, success in building on the assets already in place in East Tennessee will enhance the economic opportunities in the entire state.

High-technology businesses typically have much more exacting location requirements than their conventional counterparts. Perhaps because of higher average wages paid and the need to recruit top staff in a national market, high-tech firms pay more attention to "quality-of-life" considerations than many other industrial concerns, and the task force believes that Tennessee offers a high quality of life.

As a part of the growing Sunbelt, East Tennessee has a range of attractive life styles and cultural experiences. The cost of living is below that of most of the more heavily industrialized areas of the country, and the climate compares favorably with most other states in pursuit of high-technology development. Unlike some other high-technology-based communities, the area has a wide range of attractive housing available at reasonable prices, and there is space for well managed growth and strong community support for this kind of economic progress.

Resource Advantages

The outdoor recreational resources of the state and region are substantially greater than those generally available elsewhere. Most of the region is within an hour's drive of the Great Smoky Mountains National Park, the nation's most visited, and seven of TVA's "Great Lakes of the South," which offer a wide variety of aquatic recreational activities. Few places in the world can boast a metropolitan area with such easy access to mountains and lakes, wilderness and wildlife, and a full range of active and passive recreational opportunities.

The cultural resources of the region are now sufficiently diverse and of a quality to meet the needs of the technical and business leaders whom the area must attract and hold. The full range of cultural programs that tend to be associated with good universities may be found in Knoxville and Oak Ridge, as well as in the state's other major cities.

Aside from all these "quality-of-life" attributes, there is yet another positive factor which contributes to the corridor's potential to attract high-tech industry. The Oak Ridge-Knoxville area of East Tennessee is already the home of a significant number of high-technology firms that have emerged from energy-related R&D activities. These businesses provide the region with a head start in developing a "critical mass" or base of interrelated firms which, because of their products, processes, or level of technological expertise, tend to attract related activity in R&D, services, and manufacturing. The energy-related technological resources of public agencies such as Oak Ridge National Laboratories and the Tennessee Valley Authority are also part of this critical mass.

Other important features of East Tennessee are its central location to many of the nation's product markets and its recently improved interstate system, as well as rail and barge transportation facilities. The state as a whole has favorable labor force productivity, generally low rates of employee turnover, an attractive tax structure, and a cooperative rapport with labor unions.

While these assets are impressive, their presence so far has not been sufficient to attract enough firms to create the types of jobs that Tennesseans need to raise family incomes. There are a few problem areas that must still be addressed, and each may be equally important in accomplishing the goal of greater economic growth for Tennessee. These problem areas include (1) manpower development, (2) a focused long-term marketing effort to inform high-technology companies of the resources in Tennessee, and (3) a formal system

for helping entrepreneurs get new businesses started.

Manpower Development

Although an adequate, technically skilled labor pool is available for current needs, an influx of high-technology industry will require expanded and sophisticated manpower training capability. More high-technology industry will also require improved and expanded technical and research programs at the state's private and public educational institutions. Advanced research and technical training programs conducted in collaboration with high-technology firms foster technology transfer, provide training for an in-state labor pool, and reflect the state's commitment to serve the needs of high-technology firms.

Marketing

A focused, long-term marketing effort is needed to inform high-technology business about the state's advantages. Business firms make relocation or expansion decisions infrequently, and only after an intensive study of alternative locations. As in a private business marketing effort, a considerable investment in time and talent must be made to identify the businesses for whom these resources are most important, identify the specialized information these businesses need to make their decisions, and to communicate that information. The successful experience of the Research Triangle in North Carolina indicates that several years of frequent contact is required just to get the full attention of the key decision makers. Presently, Tennessee is not thought of in the context of high-technology by key decision makers. Our other assets, mountains and lakes, the parks, and our sports and country music heritage, are well known. Our true status with respect to science and engineering must be made equally well known.

New Business Assistance

The third critical area for institutional improvement is the support required for new start-ups, particularly in new or emerging technologies. There have been numerous instances where R&D efforts or technological advances were pioneered here only to be commercialized elsewhere because of a perception that Tennessee lacked venture capital or other management support services generally required by entrepreneurs.

Over the long term, home-grown businesses can be the most important basis for prosperity and stability in a community, yet the task force found that commercialization and technology transfer assistance have been underemphasized elements in the range of services provided to new or expanding high-technology industries by Tennessee, as well as by most of its competitors. A strong thrust in this area of assistance could provide Tennessee with a significant edge on the competition. To accomplish this, a small business development organization is necessary. It should be staffed by a maximum of two or three people who can attract the interests of potential entrepreneurs and then see that they have easy access to the help they need. The people and resources to provide this help – business plans, technical and market evaluations, and venture capital – are available in the area, and the function of the business development organization should be to assist the budding entrepreneur in gaining access to the resources his business requires.

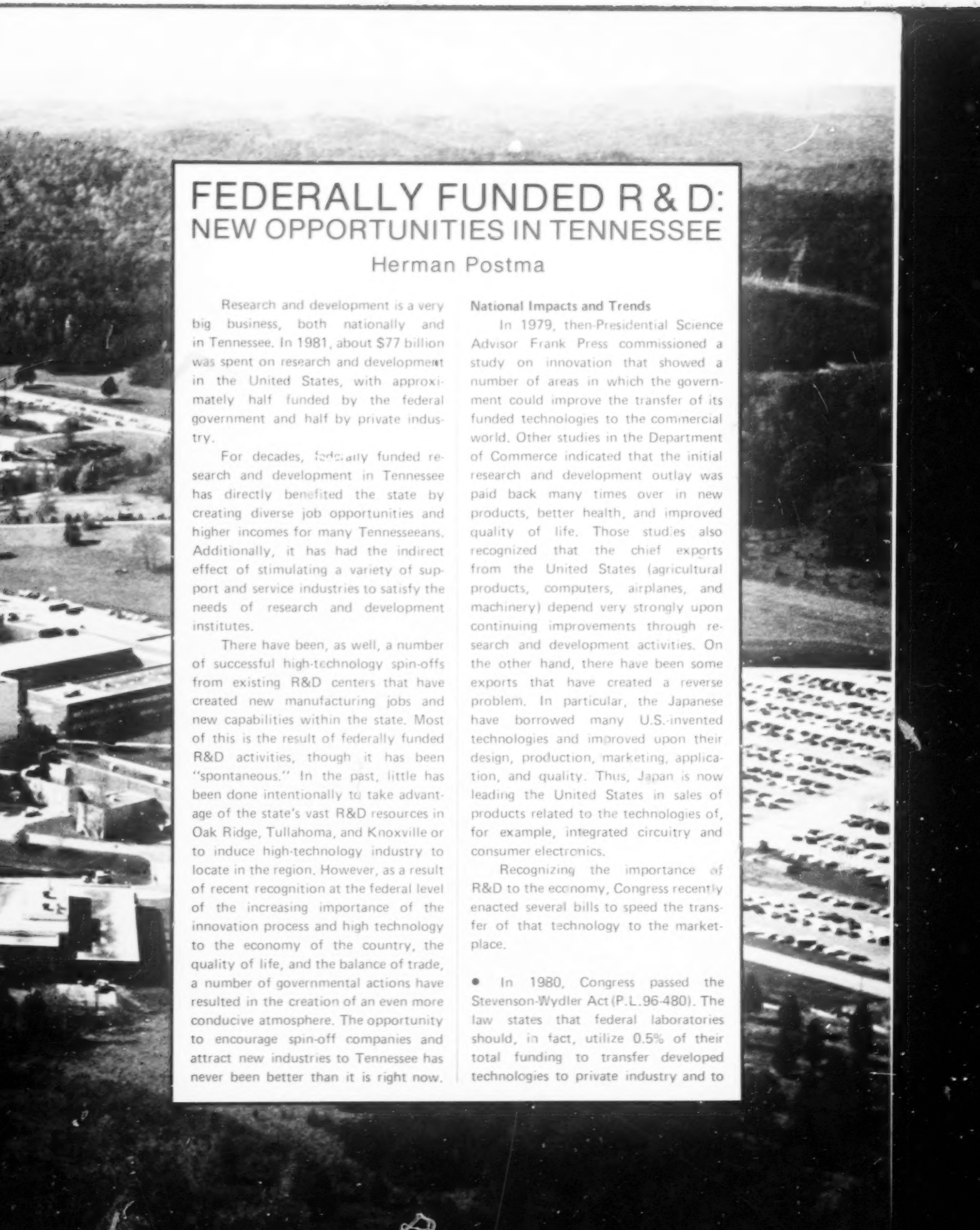
Other Thrusts

In addition to these new initiatives, others already underway must continue. The University of Tennessee is making progress with a program of promoting centers of excellence in science and engineering. This program will not only serve the University's teaching and research functions, but will also attract the attention of business firms which need the support of an outstanding university. A new campus for the State Technical Institute at Knoxville will provide an opportunity to develop a showcase institution that can demonstrate the state's commitment to providing its citizens with the technical skills required by high-tech firms. The planned extension of the Pellissippi Parkway from Interstate 40/75 to the metropolitan airport in Blount County will help meet another of the criteria required by high technology: good access to commercial air transportation. It will also open up additional land ideally suited for the high-quality, campus-like development that most high-tech firms seek.

It is important to note that most of the actions recommended by the task force are state projects already in the planning stage, requiring their own appropriations. If implemented as a part of the Technology Corridor, the Parkway extension, as well as the proposed campus, will add no further costs above or beyond what these projects would cost if funded and constructed independently. By including them in an integrated package, however, the task force believes the state will achieve a significantly higher return on its investment.

"Packaging"

In summary, "packaging" is perhaps the key to the ultimate success of the state's pursuit of high-technology economic development. Tennessee has the resources: a favorable climate, a pleasant and affordable living environment, diverse cultural and recreational resources, "critical mass" in selected technological fields, emerging centers of excellence in post-secondary education institutions, and a favorable business climate. The state, in general, and the Oak Ridge/Knoxville area, in particular, have all of these attributes, but they simply have not yet been adequately analyzed and communicated in a manner that makes Tennessee appear to be the ideal place for high-technology industry that it actually is. Other areas of the country have successfully capitalized on far fewer advantages. With the establishment of an organization to orchestrate the state's resources, provide support for the establishment and growth of new businesses, and recruit high-technology industry, Tennessee can utilize its as-yet untapped potential for accelerated economic development for the ultimate benefit of all its citizens.■



FEDERALLY FUNDED R & D:
NEW OPPORTUNITIES IN TENNESSEE

Herman Postma

Research and development is a very big business, both nationally and in Tennessee. In 1981, about $77 billion was spent on research and development in the United States, with approximately half funded by the federal government and half by private industry.

For decades, federally funded research and development in Tennessee has directly benefited the state by creating diverse job opportunities and higher incomes for many Tennesseeans. Additionally, it has had the indirect effect of stimulating a variety of support and service industries to satisfy the needs of research and development institutes.

There have been, as well, a number of successful high-technology spin-offs from existing R&D centers that have created new manufacturing jobs and new capabilities within the state. Most of this is the result of federally funded R&D activities, though it has been "spontaneous." In the past, little has been done intentionally to take advantage of the state's vast R&D resources in Oak Ridge, Tullahoma, and Knoxville or to induce high-technology industry to locate in the region. However, as a result of recent recognition at the federal level of the increasing importance of the innovation process and high technology to the economy of the country, the quality of life, and the balance of trade, a number of governmental actions have resulted in the creation of an even more conducive atmosphere. The opportunity to encourage spin-off companies and attract new industries to Tennessee has never been better than it is right now.

National Impacts and Trends

In 1979, then-Presidential Science Advisor Frank Press commissioned a study on innovation that showed a number of areas in which the government could improve the transfer of its funded technologies to the commercial world. Other studies in the Department of Commerce indicated that the initial research and development outlay was paid back many times over in new products, better health, and improved quality of life. Those studies also recognized that the chief exports from the United States (agricultural products, computers, airplanes, and machinery) depend very strongly upon continuing improvements through research and development activities. On the other hand, there have been some exports that have created a reverse problem. In particular, the Japanese have borrowed many U.S.-invented technologies and improved upon their design, production, marketing, application, and quality. Thus, Japan is now leading the United States in sales of products related to the technologies of, for example, integrated circuitry and consumer electronics.

Recognizing the importance of R&D to the economy, Congress recently enacted several bills to speed the transfer of that technology to the marketplace.

- In 1980, Congress passed the Stevenson-Wydler Act (P.L.96-480). The law states that federal laboratories should, in fact, utilize 0.5% of their total funding to transfer developed technologies to private industry and to

help state and local governments utilize that technology.

- In 1980, Congress passed the Bayh-Dole Act (P.L. 96-517), which granted universities and other not-for-profit institutions additional lenient patent rights for federally funded inventions, thereby encouraging further development and licensing. As a result of that bill, coupled with financial pressures, universities have recently joined in a host of new partnerships with several large corporations (primarily in biomedical research). Stable funding of several million dollars per year is promised by the corporations which receive, in return, first rights to any discoveries.

Recent examples of corporate/university research and development relationships are the following:

-- The Council of Chemical Research was formally established as a not-for-profit organization to gather industrial financial support for R&D in university chemistry and chemical engineering departments. Already more than 20 companies and 60 universities have signed, with a goal of 40 companies and 100 universities by the end of 1982.
-- Exxon announced a $15 million fund for research in universities. In October 1981, Arco and others followed the example.
-- DuPont gave a $6 million grant to the Harvard Medical School for molecular genetics research.
-- Hoechst gave a $50 million grant to Massachusetts General Hospital for medical research.
-- The state of North Carolina, its universities, and General Electric formed a $25 million microelectronic research center in 1981 at Research Triangle Park.
-- In December 1981, Technion gave $100 million to Massachusetts Institute of Technology for a biomedical research institute.
-- Westinghouse and others are supporting a robotics center at Carnegie-Mellon University.

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- Presently, Congress is considering two companion bills – the Schmitt-Ertel bills (Senate 1657 and House Resolution 4564) – that would allow exclusive patent rights to be easily granted to large, federally funded contractors. The more rapid entry into the marketplace and exclusivity thus granted would reduce risk and stimulate private sector development.
- Another recent bill, the Small Business Innovation Research Act of 1981 (Senate 881 and House Resolution 4326), is given a good chance for passage in 1982. It would require each federal agency to set aside 1% of its budget specifically for small R&D enterprises. This is designed to aid small business through the commercialization of new technologies. However, a recent General Accounting Office report states there is insufficient data to support the assumption that commercialization will actually occur.
- Finally, the Economic Recovery Act of 1981 substantially liberalizes tax writeoffs for new corporate investments in R&D as well as for money spent by corporations for R&D performed by universities.

The net result of these actions is that the stage has been set for more innovation, easier granting of patent rights, and additional financial stimuli for performing research and transferring the resultant technology. Venture capital limited partnerships are being formed for R&D in a number of areas as a result of these stimuli. However, whether markets exist and whether production, quality, productivity, and marketing thrusts – all crucial factors in getting a new product sold – can similarly be improved remains to be seen.

Research and Development in Tennessee

Most of the research and development performed in the state of Tennessee is funded by the federal government. Those institutions within the state in which federally funded R&D is performed include the following: the principal graduate-degree-granting universities of the state (The University of Tennessee, Knoxville; Vanderbilt University; The University of Tennessee Center for the Health Sciences, Memphis; Meharry Medical School, Nashville; and Memphis State University); the research and development complexes of the Arnold Research Center and The University of Tennessee Space Institute at Tullahoma; the Tennessee Valley Authority (which derives its funds both from Congressional appropriations and from power revenue); and the research and development complex at Oak Ridge.

The total amount of research and development funding in Tennessee is approximately $800 million per year, placing it fifteenth among all the states. Moreover, federal R&D funds to Tennessee institutions have grown at an annual rate of 15% per year during the last decade – a growth rate approximately two and one-half times the national average. This is the second-highest growth rate for those states which receive more than $150 million per year, though the state trails substantially behind California in the total amount spent. Table 1 provides more details on funding and its allocation within the state.

It is far more difficult to obtain reliable estimates of private-sector-funded research and development performed in Tennessee, either within industry located in the state or in Tennessee universities. This is because corporate R&D data are not broken down by state (nor willfully disclosed). In any case, the amount of industrially funded R&D within the state, though substantial, is very small compared to the federal R&D expenditures, and even smaller compared to the amount of private sector R&D performed in industrially R&D-intensive states such as

TABLE 1

RESEARCH AND DEVELOPMENT FUNDING IN TENNESSEE

Source	1981 Funding in Millions of Dollars
Federally Funded (Total)	800*
TVA (appropriated by Congress, other agencies)	16
The University of Tennessee Space Institute, Tullahoma	9
Sverdrup (ARO)-Calspan-PanAm, Tullahoma	120
Memphis State University, Memphis	5
The University of Tennessee Center for the Health Sciences, Memphis	12
The University of Tennessee, Knoxville	19
Vanderbilt University, Nashville	22
Meharry Medical School, Nashville	10
Oak Ridge Associated Universities, Oak Ridge	15
Union Carbide Corporation-Nuclear Division (various), Oak Ridge	125
Union Carbide Corporation-Nuclear Division (Oak Ridge National Laboratory), Oak Ridge	350
Privately Funded (Total)	130
Tennessee Eastman, Kingsport Technology for Energy Corporation, Knoxville Precision International, Tullahoma EG&G ORTEC, Oak Ridge Combustion Engineering, Chattanooga Boeing Corporation, Oak Ridge	100†
TVA (power revenue)	22
Various universities	7

*Total is from National Science Foundation. Counts equipment and capital as well as operating. Details from personal contacts; operating only.

†Estimate developed from private contacts; operating only.

New York, California, and North Carolina.

A rough estimate of the amount of private sector R&D funds spent in Tennessee is approximately $130 million per year. Tennessee Eastman in Kingsport leads a list which includes such firms as Combustion Engineering in Chattanooga; Technology for Energy Corporation in Knoxville; EG&G ORTEC and Boeing Corporation in Oak Ridge; Precision International in Tullahoma; American Enka in Lowland; Great Lakes Carbon in Elizabethton; Humko, Buckeye Cellulose, and Plough, Inc. in Memphis; and the Hospital Corporation of America in Nashville. Private-sector R&D funds going to The University of Tennessee, Knoxville, amount to $700 thousand per year, or 3% of their total R&D funds; to Memphis State, about $2 million per year; and to Meharry Medical School, approximately $4 million per year.

User Facilities

An important attribute of federally funded research and development is that it creates unique facilities which are usually large, complex, sophisticated, and expensive – precisely the kinds of facilities that are not likely to be created by a single industry, group of industries, or, in particular, the small entrepreneur. Yet, in many cases, these facilities fill a gap in the knowledge that industry must have of its products and the understanding of phenomena that could lead to new product development. In most cases, federal facilities were originally intended to perform specific research in a particular area, but over the past two years they have been made available to industries and universities to perform work with a potential for commercial impact. Procedures have been developed to allow the performance of proprietary research by industry at federal facilities by special permission. Access has been greatly eased through a number of precedent-setting actions which have taken place during the last two years. Though some user facilities exist at other federal research establishments, the majority are at the National Lab in Oak Ridge. A few examples follow.

- Oak Ridge has unique facilities for studying the properties of polymers such as plastics and rubbers. A detailed knowledge of the properties of polymers is important in understanding how they are created and how new products may evolve from that understanding. DuPont and Firestone have recently used these facilities for proprietary research. AT&T and IBM have performed nonproprietary research using the same facilities.
- Other facilities use sophisticated ion implantation methods to harden materials to make improved tool steels for machining, to harden and make corrosive-resistant and nearly friction-free alloys, and to create new semiconductors. Users of these facilities have been Exxon, IBM, Motorola, RCA, AT&T, and others.
- Unique microscope diagnostic tools have been used by industry to study new alloys and structures of ceramics. Included among the users are Rockwell International and Westinghouse.

- Unique bacteria facilities that grow biologically active materials and separate the products have been used by pharmaceutical and chemical companies to exploit entirely new technologies for rapid separation of useful materials and drugs in large quantities.

The benefit to potential users within the state of Tennessee is the accessibility and geographical proximity of unique facilities. In fact, to use the facilities, companies come to Oak Ridge from almost every state and some foreign countries. This factor alone creates a new awareness of the technological capabilities of the state and forms new ties that could be beneficial in the subsequent location of high-technology industry in areas where accessible, unique facilities are located.

Impacts through Spin-offs and Ancillary Developments

There are, obviously, important direct benefits from the location of intensive R&D within the state, primarily through the employment of Tennessee-trained scientists and engineers. However, there are a number of other very important effects resulting from the location and performance of R&D in the state. For example, a considerable number of sophisticated support and service industries are located near these research and development centers. Actual procurement of services and goods within the state is an important statewide benefit. Other, indirect benefits are spin-off industries, visitors, and attractiveness to high-technology manufacturing groups which prefer to locate near centers where technology is rapidly evolving (agglomeration economies).

One important natural result of centers of research and development is that new ideas evolve which lead to new commercial products and services. These spin-offs traditionally occur through the entrepreneurial bent of an individual or group of individuals. Already there are a number of examples of spin-offs from research in Tennessee. A recent survey in the Oak Ridge area of spin-off firms or businesses which manufacture new commercial products or provide services revealed that current employment in those firms is approximately 1500. A few examples illustrate the variety:

- A recent spin-off firm – Technology for Energy Corporation (TEC) – was featured in the December 1981 issue of **Inc.** magazine as the fourth fastest-growing, privately held small business in the United States, with an annual growth rate for the last five years of 182% and sales in 1981 of $15 million. Principal sales are in computer-based diagnostics and analysis of functions for utility power plants, which help optimize the reliability and safety of those plants. In addition, TEC provides custom services to a variety of energy companies, principally electric utilities, and employs over 200 people. Inventions, ideas, and staff members of the Oak Ridge National Laboratory and The University of Tennessee, Knoxville provided the impetus for formation.
- In the early 1960's, a group of entrepreneurs in Oak Ridge formed ORTEC, which was later acquired by EG&G of Boston. Its principal product now is instrumentation used in energy research and in medical diagnostics. Current employment is about 500.
- Boeing Corporation, which improved on the centrifuge manufacturing process used to enrich uranium for nuclear reactor fuel, recently built a $60 million manufacturing facility in Oak Ridge which employs 300 people.
- There are similar success stories at Tullahoma, where Arnold Engineering, doing federally sponsored aeronautical research, and The University of Tennessee Space Institute have stimulated spin-off and ancillary developments:

  — Precision International, an instrumentation manufacturer, now employs 150 people.

  — Keuffel and Esser Company, which manufactures sophisticated distance-measuring devices as well as medical electronics, employs 120 people.

  — Sverdrup Technology, an engineering consulting firm, has more than 200 employees.

  — Microcraft, an experimental-model-testing firm, employs 50 people.

These businesses, and especially the large federal establishments, have stimulated support services such as analytical laboratories, precision machine shops, and other suppliers, largely operated by local entrepreneurs.

In addition, a variety of branch offices have been established which provide high-technology services and support. Some national scientific engineering and consulting firms which have been attracted to the Oak Ridge area include Bechtel, Fluor, Gilbert Commonwealth, Lockheed Corporation, Science Applications, Inc., System Development Corporation, and TRW. These firms originally came to the area to supply sophisticated services and support to federal programs but have evolved to provide similar services to private corporations within the Southeast. For example, Bechtel has established a 200-person branch office of its San Francisco headquarters in Oak Ridge to provide broad services throughout the region. Through diversification, such support firms are breaking their dependence on the sometimes volatile cycle of federal government expenditures.

Fostering Local Spin-offs and Attracting New Industries

Conditions which allow the entrepreneur to spin off from research and development and develop a successful commercial enterprise involve a combination of factors. These include waivers of patent rights and availability of an infrastructure to assist all aspects of business development, including engineering, finance, marketing, and production. New ventures need assistance in business planning, securing sources of capital, and obtaining the managerial leadership necessary to succeed.

Within The University of Tennessee system, the Research Corporation was formed to encourage and facilitate the obtaining and marketing of patents and copyrights for UT faculty. Together, Research Corporation and the

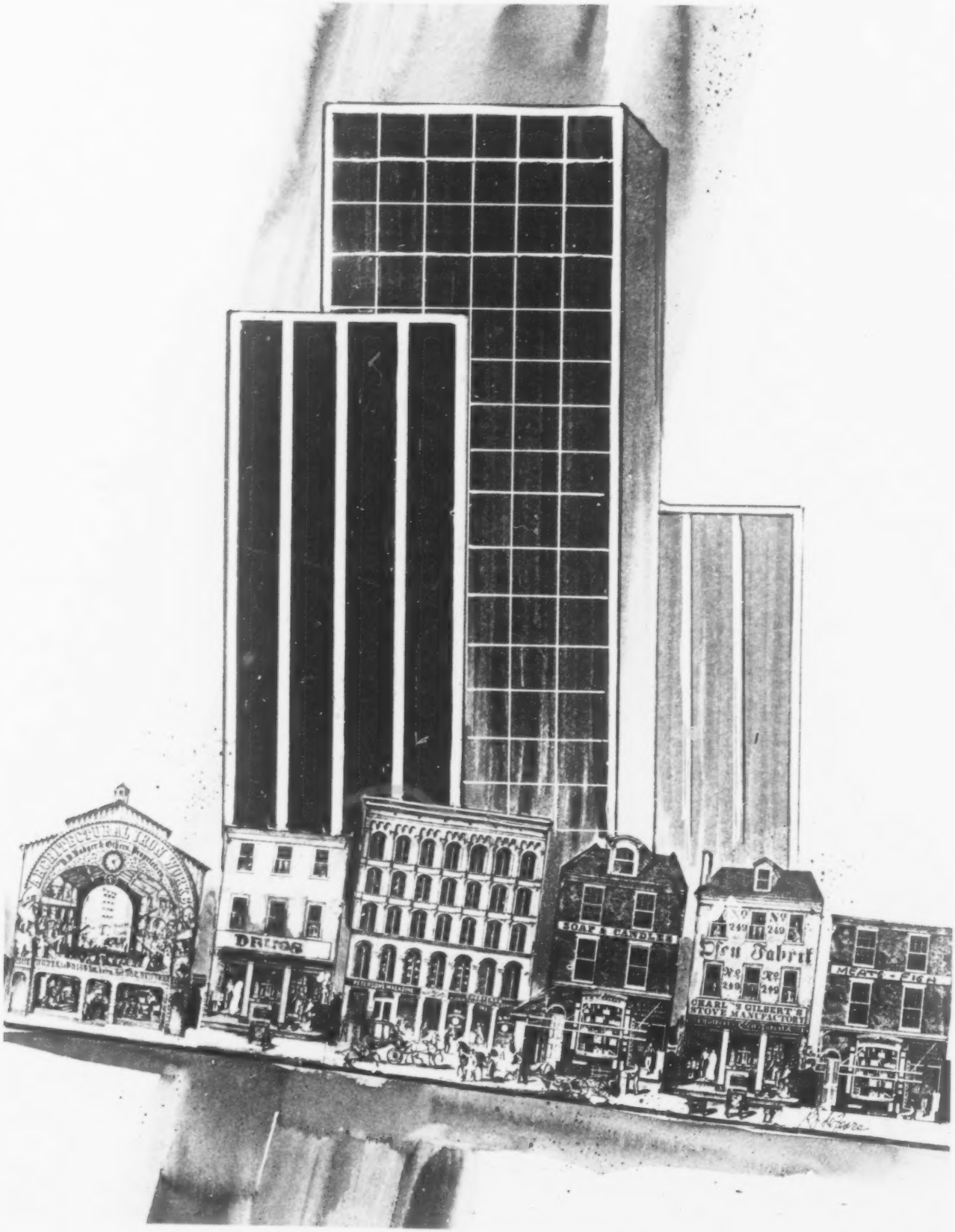
Here, UTK physics and chemistry professors work with fellow scientists at ORNL on a chemical bonding process which could lead to the development of a permanent and safe way to store nuclear waste.

University have the capability (including accessibility of incubator space, technical libraries, consultants, management planners, lawyers, capital, and unique facilities) to initiate actions that would lead to more successful private development. The first biotechnology corporation spin-off from The University of Tennessee, Knoxville – Phyton Technologies, Inc. – began operation in Knoxville this spring to propagate plants using tissue culture methods. Others are now being chartered and constitute an area of development with considerable promise for the state.

A group called Energy Opportunities Consortium in Knoxville has aided the entrepreneurial process in the private sector and a new not-for-profit group is presently being set up in the Knoxville/Oak Ridge area to aid spin-offs and entrepreneurs from government-funded R&D facilities as well as existing high-technology businesses.

In addition to local spin-offs, one very important benefit from this high-technology R&D already in the state should be the ability to attract new industries from outside the state. Large research and development and high-technology manufacturing complexes have been created at Research Triangle Park in North Carolina; Route 128 near Boston, Massachusetts; and Silicon Valley near Palo Alto, California. Several other states, particularly Texas, recognizing the economic benefits these high-technology industrial centers bring to an area, are trying to duplicate this experience.

Many of the benefits of attracting this kind of new industry to Tennessee are already evident, particularly in East Tennessee, where the combination of unique facilities for federal research, existing high-technology industry, strong research capability at The University of Tennessee, and a large professional staff at TVA are available. These resources enhance the already great potential for job and income growth. Local leaders have been encouraged to combine talents and energies across political boundaries and to see future development as regional rather than local. If this effort to develop a "Technology Corridor" within Tennessee is successful over the long run, its benefits will be felt across the entire state. ■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Developing A High-Tech Complex Through Small Company Formations

Albert Shapero

The United States is rediscovering that the formation of new firms is critical to a self-renewing economy. Recent studies have stressed the vital contribution of these young organizations to innovation and job growth in the nation. A survey by the American Electronics Association, for example, revealed that firms from ten to 20 years old had 20 to 40 times the job growth rate of older firms; firms between five and ten years old, 55 times the job growth rate; and firms less than five years old, 115 times.

In addition, a National Science Foundation study concluded that small firms produced 24 times as many major innovations as large firms and four times as many as medium-sized firms. Small companies were also found to be more efficient producers of innovations, with a ratio of innovations to R&D employment four times that of large firms. The bureaucratic behavior of large companies is typified by risk avoidance. There is an increasing interest in acquiring smaller firms that have already taken the risk and developed both product and market. Furthermore, large firms tend to be capital intensive and are engaged wherever possible in getting more done with fewer people and in substituting capital for labor, thus reducing the number of jobs.

Company Formation and Local Economic Development

From the standpoint of local area development, new company formations can endow communities with a source of long-term economic health. The qualities characteristic of or generated by entrepreneurship are resilience, creativity, initiative-taking, and, above all, diversity. *Resilience* is the ability to absorb abrupt changes in the economic, social and political environment and to bounce back; *creativity*, the ability to create anew and to experiment; *initiative-taking*, the desire and ability to begin and carry through useful projects; and *diversity*, the ability to undertake a variety of enterprises that assure that no single event can affect the whole community.

Every company formation is a creative act and bears with it an innovation in terms of product, service, method of doing business, location, or appearance. Every company formation is the result of initiative-taking.

Programs to elicit and support new entrepreneurs and the company formation process in a locale offer potentials not readily available through other approaches, including the following possible developments:

(1) An area capability for fielding appropriate responses to events in the marketplace as they occur. A successful tradition of responding to opportunities by starting new companies gives an area the means for dealing positively with a wide variety of possible future events rather than trying to base strategy on projected or predicted events. It is essentially a case of developing a response capability rather than of developing specific responses to projected futures.

(2) An actuarial approach to events. A multiplicity of companies, as opposed to one or two major corporate divisions, provides an area with a number of independent decision-making units, each assessing the environment from a somewhat different vantage point, thus increasing the likelihood of evolving appropriate responses. In contrast, a large corporate division represents one decision point in a community, with a high likelihood that decisions will be made from a viewpoint that is not locally oriented.

(3) A greater tendency to innovate. Each new company is an invention or innovation in itself, and each new formation (and innovation) raises the probability of a consequent one occurring. Furthermore, there is an extensive history of innovations, particularly high technology innovations, generated and/or brought to the marketplace through new companies. From the viewpoint of society, entrepreneurship gives operational expression to new ideas, new structures, new products, and new devices.

(4) Valuable social learning at very little political and economic risk. A failed enterprise may be a highly traumatic experience for the founders and those who have financial stakes in the enterprise, but it is seldom a net loss for the community in which it occurs. Each failed enterprise is a generator of social learning for all those who have been associated with it. Empirical studies of company formations have shown that many successful entrepreneurs failed at least once before their current success.

From the viewpoint of the concerned public official, a program to encourage new company formations is a relatively low-risk and potentially high-gain effort. It shifts attention and responsibility to the successes and failures, in aggregate, of the many company formation efforts (another actuarial aspect). A program that generates several entrepreneurial formations distributes the political and economic risks over a large number of smaller and less visible points than does a program that is focused on one or two large, expensive, highly visible, long-term projects.

(5) Cultural fit. The entrepreneur, even one who is a member of a minority or immigrant group, is part of the fabric of the culture in which he is found. He lives close to and is part of the culture

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of the country, region, and locale, is attuned to place and custom, and has an intimate awareness of what can or cannot be done with local resources.

The local entrepreneur is more likely to bring a special passion and devotion to his efforts in a locale which affects his willingness to "hang on," his desire to do something for the locale, and his willingness to forego the maximization of some particular economic variable that would require relocation in some other area.

The Company Formation Process

Each year hundreds of thousands of new businesses are formed in the United States. Though each formation is a unique event, examination of the data for a large number of company formations in different countries, regions, and economic sectors suggests that there is a fairly consistent general pattern for the company formation process. The general pattern includes four major elements: (1) *displacement* of the nascent entrepreneur(s); (2) an apparent *disposition to act* on the part of the nascent entrepreneur(s); (3) examples or models of behavior that impart *credibility* to the act of forming a company for the nascent entrepreneur(s); and (4) *availability of resources* to the nascent entrepreneur(s) for starting a new company.

Displacement. The formation of a company is a distinct, discrete event that requires explicit legal, financial, and organizational actions on the part of its founders. Yet, of the many company formations studied, few were found to have resulted from a rational, calculated, carefully planned succession of decisions and actions. How, then, is the company formation process initiated? We find that most company formations are associated with some kind of personal displacement, some dislodgement from a comfortable or otherwise acceptable state of being, or are begun during a period when the founder is between projects, not yet lodged in an acceptable state. The displacements that initiate the company formation process can be both negative and positive, externally imposed or internally perceived, and it is often a combination of negative pushes and positive pulls that combine to precipitate the actions leading to the formation of a company.

Negative factors appear to be far more instrumental in precipitating entrepreneurial actions than are the positive factors that loom so large in the literature on rational approaches to starting a new company, such as perceived market opportunities. There are a number of negative antecedents — political or religious exile from work, home, culture and language; displacement from a job or the expectation of termination; or transfer to another city. Even the experience of a person whose job remains static while colleagues are promoted may be perceived as a relative displacement.

Disposition to Act. Many people are displaced, but a relatively small number of them react to displacement by undertaking to form a company, or, for that matter, to take any major initiative with regard to their own futures. Several theories explain the psychological differences between entrepreneurs and non-entrepreneurs. Some suggest reluctance to accept authority imposed by others. Some attribute entrepreneurial behavior to those with a high need for achievement.

Another approach suggests that company formation is related directly to whether or not the individual feels that it is possible for him to affect events, to affect the world around him. Though researchers use different assumptions and different measuring instruments, all agree on the presence and strength of the desire for personal control of the environment by entrepreneurs.

Imparting credibility to the act. Not everyone who is displaced and has a propensity to act turns his mind to starting a new company. It means trading the familiar for the unfamiliar, accepting a large measure of uncertainty, undertaking long-term financial obligations, commitment to long hours, and a good possibility of failure.

The most potent variable found associated with the company formation act is the credibility of the act to the nascent entrepreneur. The individual must be able to see himself starting and operating a company. From the data available it can be inferred that credibility is achieved primarily by means of credible examples: company formations by someone "like one's self" or by someone with whom one can identify, someone drawn from the nascent entrepreneur's family or one of his reference groups, such as classmates or colleagues.

Many of the entrepreneurs studied were found to have formed more than one company, and many had experienced previous business failures. Failures apparently do not diminish the credibility of the company formation act, and may even reinforce the credibility of the act to the entrepreneur (as well as serving as a learning experience).

The availability of resources. Initiative-taking, the disposition to act, and credible examples are necessary but not sufficient for the formation of a company. The final required ingredient is resources. The company-forming entrepreneur must directly possess the labor, materials, equipment, and facilities required for the potential venture or must obtain them by use of his own or other people's capital.

If private or public venture capital sources are not available for certain kinds of industries, companies, or entrepreneurs, fewer companies are formed or survive. The great majority of capital for new companies comes from the savings of the entrepreneur or his family and friends, or from personal bank loans. Such sources account for over 90 percent of the initial financing for new ventures in the United States.

New ventures almost never receive financial support from formal financial institutions. Banks are constrained to treat new company financing as "not bankable," though there are some exceptional examples. According to an earlier National Science Foundation-sponsored study, U.S. venture capital firms were found to make an average of just under three investments a year, less than 15% of them for new ventures.

Since there are fewer than 1000 of these highly publicized firms in the U.S., they can account for only about 450 start-ups. Even adding in the SBIC's, the special programs for minority entrepreneurship and various Federal programs, it is obvious that the role of the formal institutions has been minuscule in the new company formation process in the U.S. Recently there have been reports of increased start-up activity by venture capital firms, but the numbers are still minute, perhaps 700 to 900 start-ups.

The Development of an Industrial Complex

The factors involved in the formation of a single company provide the basic building blocks in the formation of an industrial complex or community, but there are other questions that need to be asked in terms of the "community of companies," as differentiated from the simple aggregation of individual company statistics. One question has to do with the kinds of companies sought.

The kinds of companies or economic efforts that are desirable for an area are those that not only bring jobs and income to the region, but those that, by their nature, will enhance the quality of an area's human capital and its long-term capability to deal with the future. The kinds of economic activity that exemplify what may be termed "high-value" companies for a community are exhibited by companies engaged in high technology, dependent on highly professional and skilled manpower.

Many economic developers regard high-technology companies as especially attractive to an area's overall development program, and a number of studies of high-technology industrial complexes provide us with some useful clues as to the way the development of an industrial complex occurs in the United States. As a result of the analysis of the data, the technical company formation process in an area was categorized into three phases, differentiated by the rate of company formation. Though the three phases were not universal, they were identifiable in the majority of cases and they provide a convenient way of examining the overall success. The three phases were identified as follows:

(1) A period in which from one to four technical companies are formed, quasi-randomly
(2) A period of accumulation and incubation in which technical companies are formed at a rate of approximately one per year
(3) A period of accelerated and sustained growth in which technical companies are formed at a rate of approximately two or more per year.

The first phase – the first company formed. The first technical company formed in a local area can be considered an almost random event, for seldom can the first formation be explained in terms of calculated decisions made by an "economic man" acting rationally. In almost every case, the first technical company is distant from its markets, and there is little chance that its support services are available in the community. Whether or not the first technical company in an area survives is a function of a number of factors, such as whether or not the founder-manager is far better than average as a manager or technical professional; whether or not the company has a product or service sufficiently unique and salable to give the company a temporary monopoly in the marketplace; whether or not the company has access to financing and support services; and whether or not they are locally available.

The quasi-random, first-company type of formation may be repeated with a second, third, and fourth company, each completely independent and even oblivious of the existence of previous companies. After the first companies are formed and have survived, however, they become sources of entrepreneurs for subsequent company formations through spin-off. Furthermore, each existing company enhances the credibility of company formation to others within the company and the community. As personal displacements are experienced by employees or those dealing with the first companies, nascent entrepreneurs are triggered to take action.

The second phase – accumulation and incubation. As the number of technical companies formed in the community increases, the technical company formation process loses its random nature and enters a phase of accumulation and incubation. There is the beginning of a technical labor pool, the market for supporting services grows and begins to attract manufacturers' representatives, and the area gains warehousing of needed supplies. Supporting services are exchanged among the technical companies in the city, and local providers of professional services become "educated" to the special character and needs of technical industries.

During this second phase of development, because of its growing technical character the area often attracts industry. A large corporate division, added to the accumulating number of locally generated companies, provides considerable impetus to the creation of a local technical labor pool, which in turn attracts suppliers and services. The presence of a local university, for example, attracts and retains technical workers. Cultural amenities such as theater, music, and entertainment play a similar role. Local facilities for education are highly important as a family attraction.

Areas that have a high tourist attraction value (i.e., the "sunshine" states, coastal resorts, etc.) have an advantage in attracting and retaining potential entrepreneurs, technical professionals, and corporate divisions from other areas. Familiarity with an area resulting from its many years of attracting tourists provides a "pull" on all kinds of industries. The primary resource in a technical activity is the technical professional work force. Given the attractive community as a location, companies experience less trouble in bringing the necessary resources to the location.

The third phase – sustained growth. The number of technical companies accumulates in an area until a point is reached in which the tech-

nical company formation process begins to sustain itself. The number of formations rises from one a year to two and more a year. Services formerly maintained as marginal operations within the companies are now spun off to provide efficient services to a community of companies. The more companies in the community, the greater the number of sources for potential spin-off and the greater the increase in the formation rate.

It is important to note that the pattern of technical company formation identified here has been derived by studying such events in counties that were neither metropolitan nor suburban. Furthermore, the data even suggest that the process may be generalized to other than technical industrial complexes, since they are primarily dependent on the individual company formation process, which has been found to be similar in many kinds of industries and many different countries and cultures.

Designing Development Policies

Can entrepreneurship be deliberately made to happen in a community? What can we affect in the process of eliciting and developing, and even attracting entrepreneurial behavior in a community? What can be done to generate the entrepreneurial events that might be a key to creating a self-sustaining, developmental process in a community and in a region?

The kinds of programs that might be undertaken to develop and bring entrepreneurship to bear on development at the local level are suggested above. Some of the elements that might be included in such programs include the following:

(1) Actions to attract small and diverse companies to a region. New companies form more readily from small companies than from large companies. Furthermore, smaller firms gain real advantage from small concessions, while larger firms must be given very large concessions. Smaller companies also generate entrepreneurs, and small corporate divisions are incubator organizations.

(2) Programs to generate new company formation. National, regional, corporate, and union programs aimed at eliciting company formations can be started far in advance of the event, making the event less calamitous and increasing the probability of company formations by preparing for them when stress is less immediate.

(3) Programs to provide the industrial "ecology" that will enable new companies to form and survive. We need to reduce the obstacles to new company formation in terms of access to capital, regulatory complexity, management inadequacies, and general attitudes toward entrepreneurship. Positive steps can include: (a) programs for educating the financial community in the risks and characteristics of new, small companies and in the requirements of different industries; (b) the development and fielding of substitutes for the various factors and services available only in very large, well established communities. (c) special efforts to attract the kinds of support services to a community that make company start-up less costly and company survival easier to achieve — machine shops, plating services, blueprinting, etc.; (d) transportation support, a sector with which many communities have much experience; (e) incubator industrial facilities with low rentals and various services on an as-needed basis.

Perhaps the most severe problem faced by the nascent entrepreneur, the new company, and the young company is obtaining the adequate capital required to bring the business into being, working capital needed to establish a foothold, and capital required for growth. Thus, in the early stages of company growth, the attitudes of local lending institutions play a critical role.

Studies of how loan officers and private investors respond to new and small businesses have uncovered wide variations in the attitudes of loan officers within a given bank, of bankers and private investors within a given city, and of bankers and private investors in different communities. However, the available studies make clear that the presence of a financial community that responds positively to new companies is a key factor in whether or not a region will generate, develop, and keep new enterprises.

These findings suggest a strong need for policy options aimed at educating the financial community, making it aware of practices followed in other communities, and developing information flows to ensure that no new or small company is turned away for the wrong reasons. This could be accomplished through special educational programs or an expert retrieval system. Under the retrieval system, a lender dealing with a new company whose product is unfamiliar to him would be connected by phone to another lender with expertise in that field.

Conclusion

Programs for promoting entrepreneurship in a community should not be targeted to a single technology. The policy focus should be on eliciting and attracting entrepreneurship in as wide a range of industrial sectors and businesses as possible in order to enhance diversity in the community.

For concerned public officials, the challenge is to create conditions that permit creative and resilient responses. Instead of trying to attract branch operations of older, established firms, communities should see that their economic development policies are more concerned with new and developing firms. They should aim at diversity and reduced dependence on one or a few sectors of economic activity. Rather than concentrating on specific firms, they should focus on creating the ecological conditions conducive to new company formations.

A program for encouraging entrepreneurial formations is a low-risk, potentially high-gain strategy. It removes direct public sector concern about the failure or success of specific enterprises and shifts attention and responsibility to the aggregate of failures and successes. The larger the number of company formations, the higher the probability of some successes and the lower the risk of loss of both resources and political coinage. ■

Applications of Modern Technology

Tennesseans have been responsible for a number of dramatic advances in the technology of fibers and textiles. These advances, particularly in the measurement of fiber quality, have aided research, funded breeding programs for improved strains of cotton, facilitated the development of standards for marketing, and contributed to higher quality textiles at lower costs throughout the world. The following articles demonstrate how technology developed by Tennessee firms like Cutters Exchange and Special Instruments Laboratories, Inc. (Spinlab) has helped convert an ancient art into the modern technology of fiber science.

THE TEXTILE INDUSTRY
Hugh G. Neil, Jr.

Rapid development has occurred in the textile industry in the past 60 years. Through microscopes, balances, test-tubes, and computers, a systematic understanding of fibers has developed: how they can be produced, analyzed, treated, and made into products for our use, comfort, and protection. Most spectacular are the results of research in the field of man-made fibers, i.e., in the improvement of forms such as rayon, acetates, nylon, polyester, and vinyl. But it is in the field of natural fibers, particularly cotton, that the most extensive advances have been made.

The difficulty of understanding cotton quality grows out of its own complexity. Cotton comes to market in a bale having an incredibly wide range of diverse qualities. A single pound – no more than can be stuffed into a quart jar – comprises 100 million or so fibers, each a single elongated cell and each an individual with its own peculiar characteristics. Some are strong as steel, others are soft; some are coarse, others are fine; some are tapered, in others walls are parallel; some are white, others are discolored or stained. Every one of these characteristics in some way governs the behavior of cotton in spinning and the quality of fabrics.

For centuries before 1930, major dependence for evaluation was placed on the cotton classer, using the hand and eye as a guide for arriving at a subjective opinion of grade and staple length of cotton. Experiences with scientists, researchers, and yarn manufacturers conveyed the need for instruments to measure, in a more objective, scientific manner, cotton grade and length and other properties such as fineness and strength.

The Founding

In early 1930, Professor N. I. Hancock, a University of Tennessee plant breeder, approached Dr. Kenneth Hertel, head of the Physics Department, looking for a device capable of measuring cotton fiber length. Hugh G. Neil, who had been a physics student under Hertel, in 1948 left his position as Senior Physicist in charge of Nuclear Instrument Development on the Manhattan Project to found Special Instruments Laboratory,

(Continued on p. 22)

THE APPAREL INDUSTRY
Sam H. Pearsall, Jr.

The apparel industry, although a $12.4 billion industry, is, by its nature, very labor-intensive. For instance, an average man's sports jacket will be subjected to some 130 different operations. Since these operations are normally performed by different operators on different machines, this implies a tremendous amount of parts handling: in fact, typically, the time spent in the manufacture of a garment is less than 20% "needle time," with the remainder being handling, placing, positioning, removing, and stacking of the components.

With its heavy requirements for labor, the garment industry in this country grew largely in southern New England and the Middle Atlantic States, where it benefited from the large supply of inexpensive immigrant labor. As labor rates and economic conditions in this section of the country changed, the industry moved first to the Southeast and then spread to the Southwest, where again low-cost labor is available. In Tennessee, there are more than 75,000 people employed in more than 450 apparel factories. In fact, it is virtually impossible to name a town of 5,000 or more people anywhere in the Southeast that does not contain *at least* one garment factory. The apparel plants, and in particular the more successful plants, are located overwhelmingly in agricultural communities of 15,000 or fewer people. This insures a pool of readily trainable local employees, largely farm wives, who are available for regular, as well as seasonal, work.

Fashion, i.e., "changing" fashion, has been both the blessing and the curse of the apparel industry – a blessing in that it stimulates a continuing demand for new "in-fashion" garments, and a curse in that it makes automation of garment production very difficult. Large amounts of capital cannot be used to produce a garment to satisfy a particular fashion trend when the life of that trend may be measured in months.

A typical apparel plant is concerned with three primary operations: cutting, sewing, and pressing and finishing. In the cutting room, where the cloth is spread many plies high on long tables and the parts cut as specified, some very dramatic changes have been made over the past several years. These

(Continued on p. 24)

(The Textile Industry, continued from p. 21)

Inc., better known today as Spinlab. The new Tennessee corporation began manufacturing commercial adaptations of Hertel instruments and later developed a complete line of electronic and mechanical devices of original design for measuring several properties of cotton for the spinning industry. Spinlab instruments were soon accepted by the U.S.D.A. for preparation of cotton standards, and government organizations throughout the world quickly followed the U.S. lead in establishing laboratories using those instruments.

Technological Advances

As recognized by Hancock and other scientists, the most important parameter that needed to be measured was fiber length. It directly affected sensitive yarn manufacturing processes and thus was a major consideration in producing, selling, and buying bales of cotton. Spinlab's Fibrograph, a cotton-fiber-length-measuring device introduced in early 1950, was the very first fiber tester to be used continuously by laboratories, and it quickly earned recognition as the standard evaluation for yarn-spinning efficiency. Continuous state-of-the-art improvements resulted in a dozen model changes — from manual devices to use of vacuum tube electronics; to transistors, integrated circuits, and on to remarkable microprocessors. Modern fibrographs make measurements with greater ease and speed. In addition, they perform calculations and give advice about how the measurement data should be used for optimum benefit, such as defining progress in cotton breeding, variety selection for planting, cultural practices in growing, best procedures in ginning and marketing, and introducing stable and efficient yarn and fabric manufacture.

Early acceptance of the Fibrograph proved that a scientific approach to fiber testing could be successful and practical. Many people considered fiber strength to be the major consideration because, obviously, only a strong fiber can produce a strong yarn. Consequently, following the lead of Hertel and Neil, Spinlab in mid-1950 produced its first Stelometer, an instrument developed by Hertel to measure both fiber strength and elongation. The instrument was unique in that it was purely mechanical, small and rugged, and used a relatively fast method of breaking a bundle of many fibers rather than the previous tedious and time-consuming procedure of selecting a single fiber at a time.

Clearly, as strong yarn cannot be made from weak fibers, fine yarn cannot be made from coarse fibers, a fact well known for ages but without technological breakthrough until the early 1930's, when it was proven that cotton fiber fineness could be determined by measuring the resistance to air flow through a fiber assembly. A simple explanation can be understood by visualizing air being passed through a tube full of sand and another tube of the same size full of marbles. The tube with sand would contain few air spaces between particles and thus would offer great resistance to air flow. Air would flow easily through the tube with marbles. Fibers of different fineness cause similar reactions and thus resistance to air flow is governed by fiber fineness. Hertel, in researching the air flow principle of fiber fineness measurement, constructed the Arealometer in 1940. Even though the instrument was not suited for high-speed testing, Spinlab began manufacture of the Arealometer in the early 1950's. Many Arealometers were made for use by research scientists worldwide.

In order to fill the need for a more rapid and practical tester for fineness, Spinlab developed the Portar, an acronym for *Port*able *Area*lometer. Although developed primarily for testing cotton, the Portar was soon recognized by the wool industry as a good method to segregate wool into fineness groups as it was sheared. Being portable, with its built-in weighing balance, manual air pump, and mechanical detector, the Portar could be used without electricity on location at the shearing shed. Since wool from the animal's back is different in fineness from the wool from the stomach, and both are different from wool from the legs, etc., the advantages of using the Portar were clear.

Other New Devices

The 1940's and 1950's were years in which tremendous strides were made in fiber technology. Development of Fibrographs, Stelometers, and Portars for commercial everyday use were stimulating achievements. Yet another instrument, the Cotton Colorimeter, was developed by the U.S.D.A. in the early 1940's. The need for the colorimeter came from the U.S.D.A.'s program to establish official standards for cotton grade, because color strongly relates to consistent bleachability and dyeability. The cotton classer's evaluation of grade was a visual determination of mixture of color, trash, and preparation or physical condition of the fibers. Spinlab's version of the Nickerson-Hunter Cotton Colorimeter has been in use since the early 1950's. It makes fast, accurate, and objective measurements of cotton color, provides a digital readout in terms of the U.S.D.A. three-digit code of color values, and is the base upon which preparation of today's U.S.D.A. cotton grade standards is dependent.

In 1981, Spinlab developed a Trashmeter to complement the Cotton Colorimeter, rapidly assisting the assignment of an instrument grade classification to bales of cotton for marketing purposes.

Modern Contributions

Contributions to modern fiber technology by Tennesseans have indeed been outstanding. The work of Hertel and his associates at The University of Tennessee, coupled with Spinlab's emergence as the prime manufacturer of fiber testers, motivated the U.S.D.A. to locate a fiber-testing and yarn-spinning laboratory in Knoxville. The laboratory is designed to support a progressive cotton breeding program aimed at improving American cottons.

Previously, about 15 years of work and patience were

Hugh G. Neil, Jr., *worked for two years at Hans Baer, AG of Zurich, Switzerland before joining Special Instruments Laboratories (Spinlab) in 1968. He became Controller Treasurer in 1970, Executive Vice-President in 1978, and is now President of Spinlab, which has offices in Knoxville and Zurich, Switzerland.*

required for a breeder to cross-pollinate a few plant flowers. He had to wait for cotton to appear, examine the fibers and plant the seeds, wait another year, and another, until enough fibers and seeds were harvested to evaluate and determine whether or not the calculations which led to the original cross-selection were correct or not. At that point he had to decide whether or not to abandon the work or continue.

A cotton breeder with two complete successes in a lifetime was envied by fellow scientists. Before the instruments' invention, the breeder's only true indicator of success was a yarn-spinning test; however, yarn spinning machinery required several pounds of fiber for processing into yarn, and the breeder had only a few handfuls from the first two or three years' work. Breeder efforts had been focused on increasing yield – more fibers per seed and more bolls per plant of cotton, but success was always offset by losses in such important qualities as fiber length.

After the instruments were introduced, a breeder's few handfuls could be tested by Spinlab instruments for those important qualities of length, length distribution, strength, and fineness; the breeder could receive early indication of whether or not his work was proceeding in the desired direction. Not until Spinlab instruments became available, especially the Fibrograph, were breeders able to measure the growth parameters that would allow them to make successful genetic changes in cotton. The reduction in time required to confirm success, combined with never-before-available scientific information about critical fiber properties, through testing, caused a massive revolution in cotton breeding – a generally unknown but historically significant accomplishment through the combined efforts of Hertel at The University of Tennessee, Landstreet at the U.S.D.A. cotton breeding spinning laboratory at Knoxville, and Hugh Neil at Spinlab. Within a period of fewer than 15 years, American cotton became recognized as the best in the world, and newly developed American varieties are now planted by almost all cotton-growing nations in the world.

Another effort by Tennesseans is recognized through the U.S.D.A., Cotton Division, Standards Branch in Memphis, where sets of cotton standards are prepared, tested, and certified. Standards for grade, staple length, Fibrograph length, length uniformity, fineness, and strength are used to stabilize what would have been an unruly and chaotic condition in world cotton evaluation and marketing.

Benefits from use of Spinlab instruments have not been confined to those in research, breeding programs, standards preparation, or cotton marketing. Fabric makers and garment manufacturers could not economically manufacture their products with today's high production machinery and quality-sensitive processes without instruments to test the fiber input and present reliable data for management decision making and corrective action. The ultimate benefactors have been consumers, protected by the innovation and timeliness of a group of Tennesseans. ■

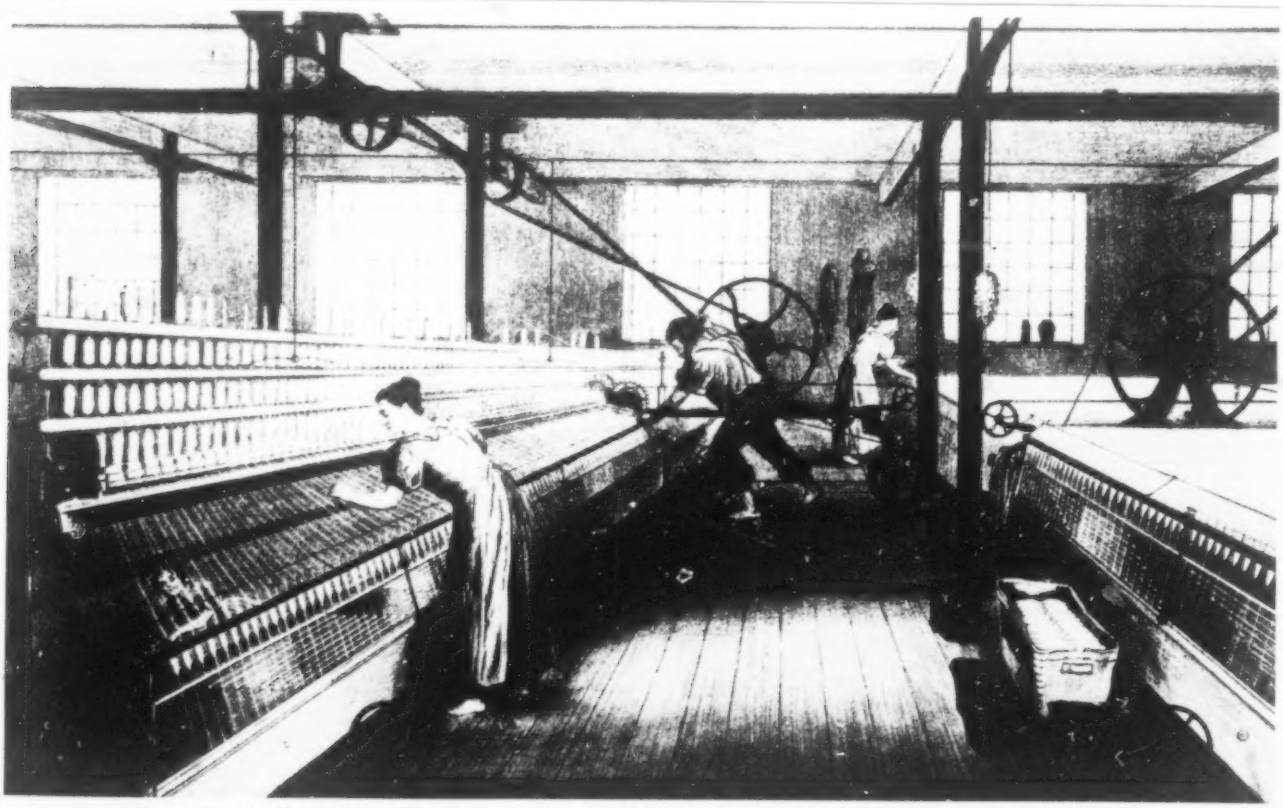

Illustration of a 19th Century Mill shows workers performing work which has since been automated through technology.

(The Apparel Industry, continued from p. 21)

operations have gone from being completely manual to using techniques that approach complete automation. The cloth can now be spread automatically to the desired length and the desired number of plies and with either the edge of the cloth accurately aligned or, in some cases, a particular stripe in the cloth aligned so that when parts are cut and assembled, the stripe pattern will match properly.

Cutting, which a few years ago was entirely a highly skilled manual operation, has, in some cases, become totally automatic. For instance, some years ago, the Hughes Company developed a laser cutting technique for use in the production of men's suits. Although this equipment was extremely accurate, the primary drawback was that laser cutting is, in truth, a burning operation and tends to fuse together the edges of the cut parts, so that it was practical to cut only one ply at a time. More recently, the Gerber Scientific Company has developed a totally automatic knife cutting operation which is capable of very accurately cutting many plies at a time. Use of this device in companies large enough to support the capital investment has increased rapidly. Both of these automatic cutting machines require that the cloth be spread very accurately on the conveyor-table for presentation to the cutting device. This has required very accurate, specially designed cloth spreading equipment of the type engineered and manufactured by Cutters Exchange.

All systems of automatic cutting require that the pattern be presented to the numerically controlled cutting head in digitized form. The generation of this digitized pattern or marker, as it is called, optimized to achieve maximum utilization of the cloth as well as to facilitate grading of sizes, has been a major contribution of computer technology to the garment industry.

An additional cutting technique utilizing extremely high-pressure, high-velocity jets of water, has been successfully used in some cutting operations such as the linings for shoes. So far, it has not proved adaptable for general garment cutting.

Whether the cutting is to be done manually or automatically, the spreading of the cloth on the cutting table is crucial for the production of accurate parts with minimum waste. Spreading machines utilizing accurate photoelectric edge controls are now standard. Other additions of electronics to these machines make possible automatic control of speed, starting and stopping, and cutting of the cloth at predetermined points. Advanced microprocessor-based control systems have made possible very sophisticated spreading machines.

The automatic spreading of cloth is not nearly so simple as it may sound, since cloth has unique properties when compared to other materials and may in addition, vary from roll to roll. Cloth, being extremely flexible, extensible by different amounts in different directions, dimensionally unstable and, in general, wound on the roll under varying amounts of tension, presents very real problems. It cannot be pushed and should not be pulled, but should be laid on the table as accurately as possible with as little tension as possible. Many technological advances have made this possible. Machines have been built which, while carrying rolls of cloth weighing over half a ton and, in some instances, over 10 feet wide, can accurately and rapidly lay it on the table. For instance, Cutters has recently completed such a machine for the totally automatic spreading of 1,200 pound rolls of Trico, 126 inches wide. The development and manufacturing of such machinery is an engineering undertaking involving not only machine design, but the most modern of electronic microprocessor control techniques.

It was previously mentioned that less than 20 percent of the total time involved in garment production is spent actually sewing; therefore, efforts to speed up the operation of the sewing machine have reached the point where the gains to be realized by further refinements are very minimal. However, costs can be reduced in the sewing operation by designing "smart" work stations so that less skilled operators may be used.

For instance, Cutters Exchange provides a microprocessor-controlled sewing aid that senses the approach of the end of a seam and then counts the number of stitches and stops so that the last stitch is precisely where it should be. This means that a relatively unskilled operator may run at a high speed in manual operation until she approaches the end of the seam, knowing that the automatic control will take over at that point and finish in perfect position. Efforts to completely automate some sewing operations, such as the setting of patch pockets, have been successful only in highly standardized garments because such machines rely on either numerical control or templates for their guidance, both of which make pattern changes expensive and time-consuming. In short, they lack flexibility. The watchword for successful "smart" sewing work stations is that the electronics be kept simple, relatively inexpensive, and that the work station be as versatile as possible.

Since about 80 percent of the sewing room time is spent in handling the pieces, the obvious place to try to reduce cost is in this area. However, it is very difficult to devise a mechanical device which will always pick up one, and only one, piece of cloth from the top of a stack. A few such devices have appeared on the market, but picking up the part is only the beginning of the problem. This dimensionally unstable and, in general, floppy piece of material must be accurately placed in position to be sewn. Thus far, automatic devices such as robots have not been able to accomplish this task.

Therefore, the present equipment utilizes a human operator to pick up and put the part into a machine. The machine then accomplishes as many operations as possible before it releases the part to a stacker. An excellent example is a machine for installing welted pockets in a man's coat. The operator is required to place the coat front under the machine in such a

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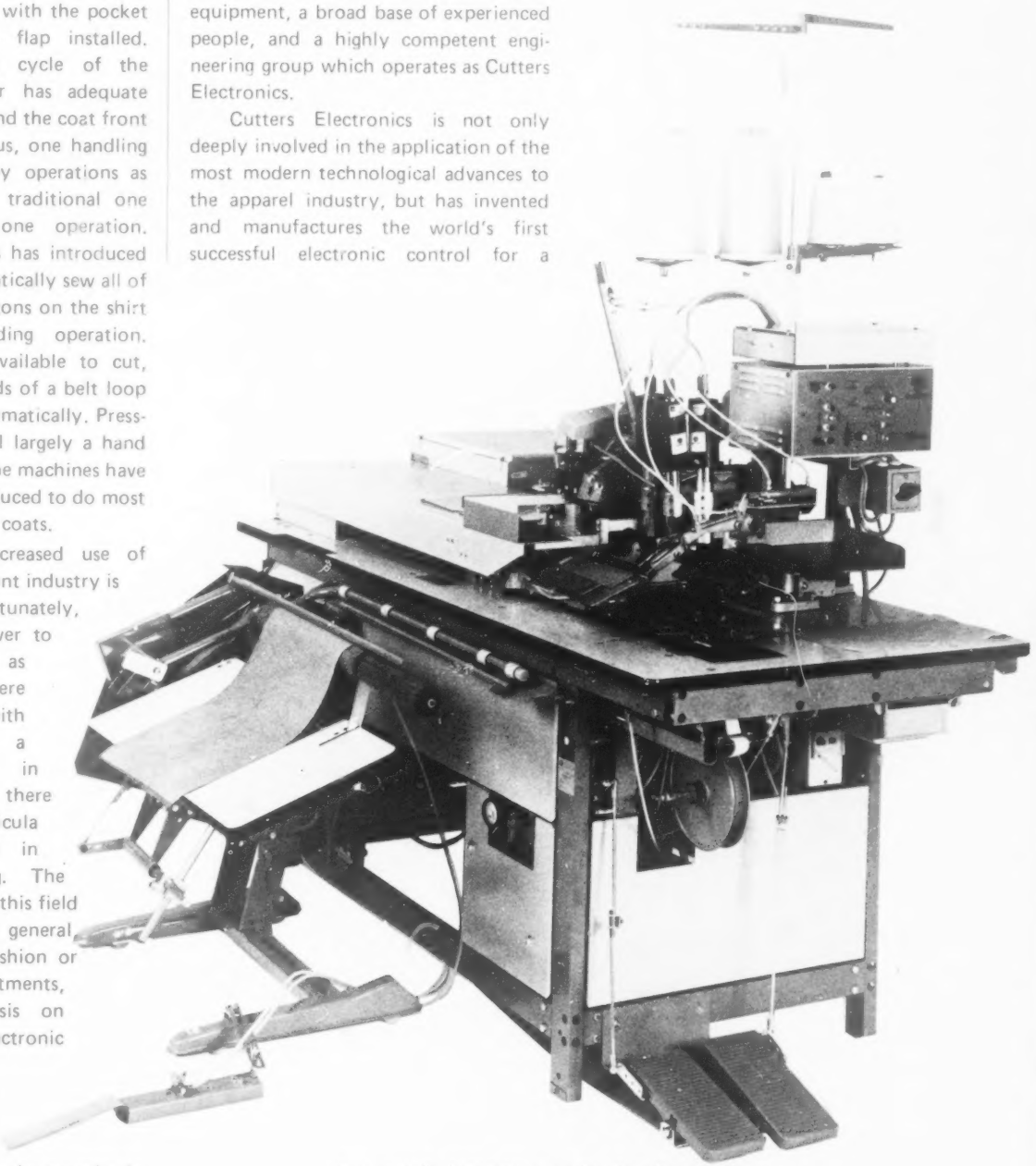
manner that the desired end locations of the pockets are located under two projected spots of light. Having done this very easily and quickly, she inserts the material for forming the welts and the pocket flap into chutes. The placement of these parts does not have to be accurate. Having aligned only the coat front, she presses a foot treadle to put the machine into operation. The machine automatically performs several distinct operations before releasing the coat front to a stacker with the pocket cut, welted, and the flap installed. During the operating cycle of the machine, the operator has adequate time to load the flaps and the coat front for the next cycle; thus, one handling has accomplished many operations as opposed to the more traditional one handling cycle for one operation.

Similarly, Cutters has introduced machines which automatically sew all of the buttonholes or buttons on the shirt front with one loading operation. Another machine is available to cut, form, and sew both ends of a belt loop to a pair of slacks automatically. Pressing and finishing is still largely a hand operation, although some machines have been successfully introduced to do most of the pressing of men's coats.

The need for increased use of technology in the garment industry is quite apparent. Unfortunately, the source of manpower to accomplish this is not as apparent. Although there are many colleges with curricula leading to a baccalaureate degree in textile engineering, there are very few curricula leading to a degree in apparel manufacturing. The schools that do exist in this field are quite new and, in general, have grown out of fashion or home economics departments, with minimal emphasis on either industrial or electronic engineering. Recruiting qualified people in this area is a major problem for the manufacturer. In fact, a major shortcoming in the apparel industry is a lack of a professional level organization devoted to technological improvement and the people responsible for it. The nearest approach in this field has been the Technical Advisory Committee of the American Apparel Manufacturers Association.

Cutters Exchange, a Tennessee corporation, is the nation's only total supplier to the apparel industry. It has access to all types of manufactured equipment, a broad base of experienced people, and a highly competent engineering group which operates as Cutters Electronics.

Cutters Electronics is not only deeply involved in the application of the most modern technological advances to the apparel industry, but has invented and manufactures the world's first successful electronic control for a cotton gin, as well as a very elaborate, computer-controlled communication system currently in use at WNET Television in New York City. It has also been responsible for the control systems which automate large portions of the production lines for man-made fibers. ■



Automatic Pocket-Welting and Flap-inserting machine

TECHNOLOGY AND AUTOMATION: THE NISSAN EXPERIENCE

Ed Miller

Currently, Nissan Motor Manufacturing Corporation, U.S.A., is building a factory of 3.2 million square feet in size in Smyrna, Tennessee, to produce 156,000 light trucks annually. This factory will be one of the most modern, highly automated, and reliable manufacturing operations in the world. The automated control system, known as NEMAC (Nissan Energy Management/Maintenance/Monitoring and Communications/Control) is being supplied by Facility and Manufacturing Automation (ORFMA) of Oak Ridge, Tennessee. Ed Miller, President of ORFMA, discusses the move to the totally integrated manufacturing facility and some of the technology involved.

For too many years, American business, particularly the industrial sector, has rested on the laurels of earlier generations, often ignoring the latest technological advances. Today, those very businesses that made this nation great are awakening to the realization that they may no longer be competitive in the marketplace.

To regain stature and remain a dominant force, American industry must change, but competition is fierce. Although many opportunities are available, the technologies which offer the greatest potential are in the area of factory automation.

Automation is a broad term, encompassing computer-aided engineering, computer-aided design, computer-aided manufacturing, the computerized office, and much more. Each of these elements is important, and all have been frequently discussed in business literature. What is really new, however, is the recent flood of technologies in the marketplace that make viable nearly any type, size, or complexity of industrial automation. There are very few process or manufacturing facilities that would not benefit substantially from some form of automation: thus, it becomes not a question of whether industry can *afford* to automate during this period of less-than-accommodating business economics, but rather, whether industry can afford *not* to automate.

There are many options, and each particular automation problem can be approached in a variety of ways. The automated control system designed for Nissan will employ a state-of-the-art computer and communications system, covering every phase of manufacturing and plant operations. For plants already making use of some computer-controlled operations, the best choices allow integration of new hardware and utilization of previously purchased equipment, with room for expansion. Nissan expects to achieve high levels of quality and productivity with this technology, and our experience has shown that a properly designed, fully integrated monitoring and control system can easily result in substantial cost savings (40 percent and more).

The Move to Network Control

The revolution to automate equipment and facilities started as a grass-roots, bottom-up approach. The desirability of replacing mechanical relays with "computer" technology led to the development of the programmable logic controllers (PLC's) or the programmable controllers (PC's), as they are called by various manufacturers. They were intended for and optimized as stand-alone, single-process, or equipment controllers. For this application they represent one of the excellent alternatives available, but the purchase of a stand-alone system every time any function or operation is to be automated turns out to be the most costly and least reliable approach.

Today, and for the factory of tomorrow, the management and operations philosophy is decidedly different. There is a trend toward plantwide integrated control. Integrated systems started to evolve when it was recognized that multiple activities and operations could be logically linked together. Initially, this occurred in a very limited manner, but recently, with the development of cost-effective, high-speed, reliable network technology, the integration of complete plants has become possible. (See Figure 1.)

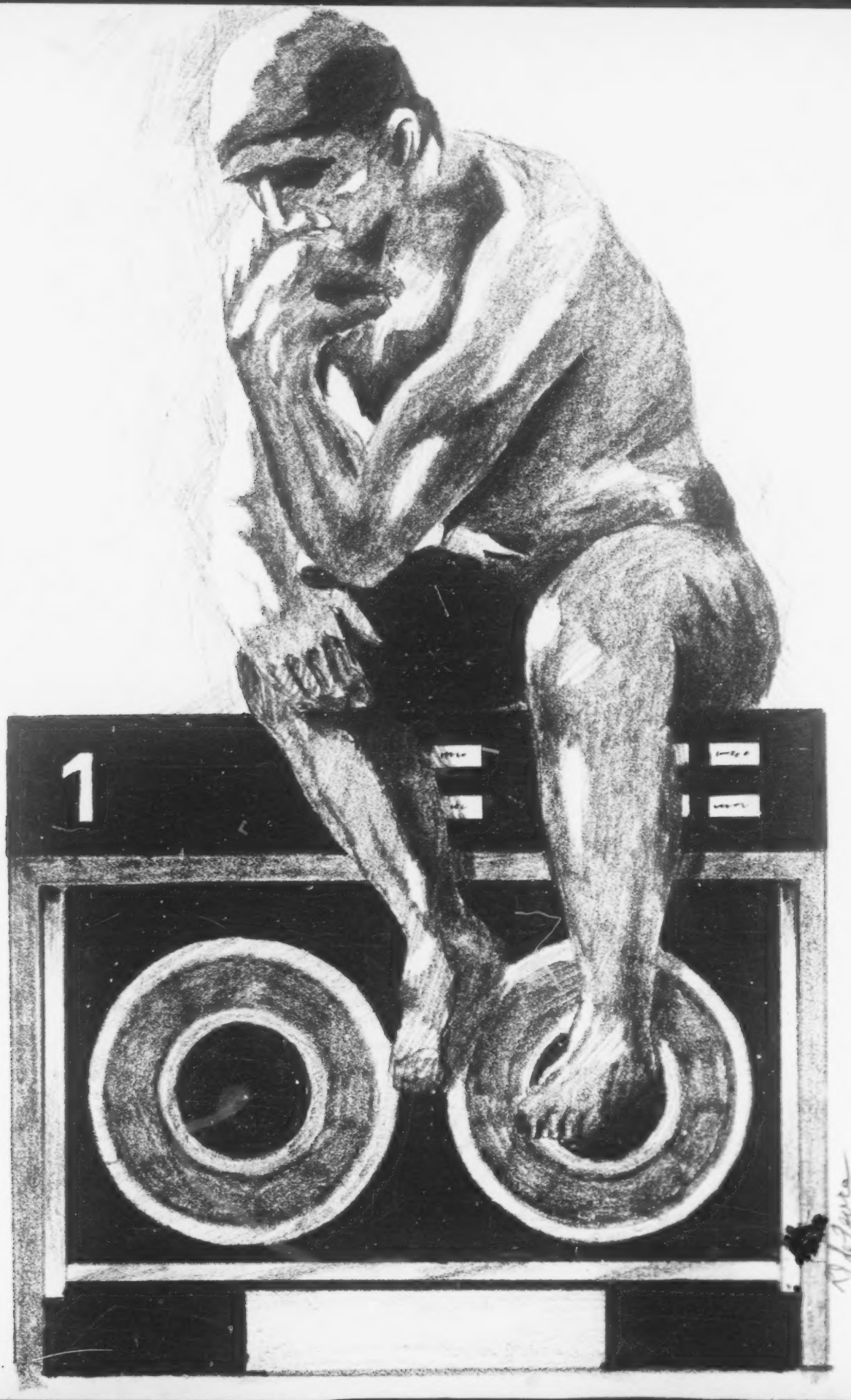
A network is the technology that links together distributed sources of processing (i.e., computers, programmable controllers, processors, robots, etc.) located within a geographically defined area. Figure 1 illustrates the variety of distributed intelligence units commonly used in a manufacturing plant that can be integrated into a network of coordinated units. Networks enable the system and its subsystems to share expensive resources such as large capacity disks, high-speed printers, memory, etc. They provide significantly more "horse-power" for each dollar expended than a stand-alone system. The networks serve as a common interface between incompatible equipment, thus freeing the user from a dependence on a single supplier. In addition, the networks can serve to gather or distribute data or other communications, such as electronic mail.

The Nissan Energy Management/Maintenance/Monitoring and Communications/Control (NEMAC) system consists of a distributed computer network which integrates all of the diverse monitoring and control functions essential to daily operations. This includes energy management, control and monitoring of manufacturing processes, fire alarm, security, maintenance dispatching, preventive maintenance, and more. The system readily interfaces to all forms of factory intelligence/ processors planned for use. The network technology which permits this undertaking is called OPTONet.

Alternative Network Technologies

The implementation of plantwide,

Ed Miller *is President of Facility and Manufacturing Automation (ORFMA) in Oak Ridge, Tennessee, whose services include engineering design and systems integration for a variety of clients.*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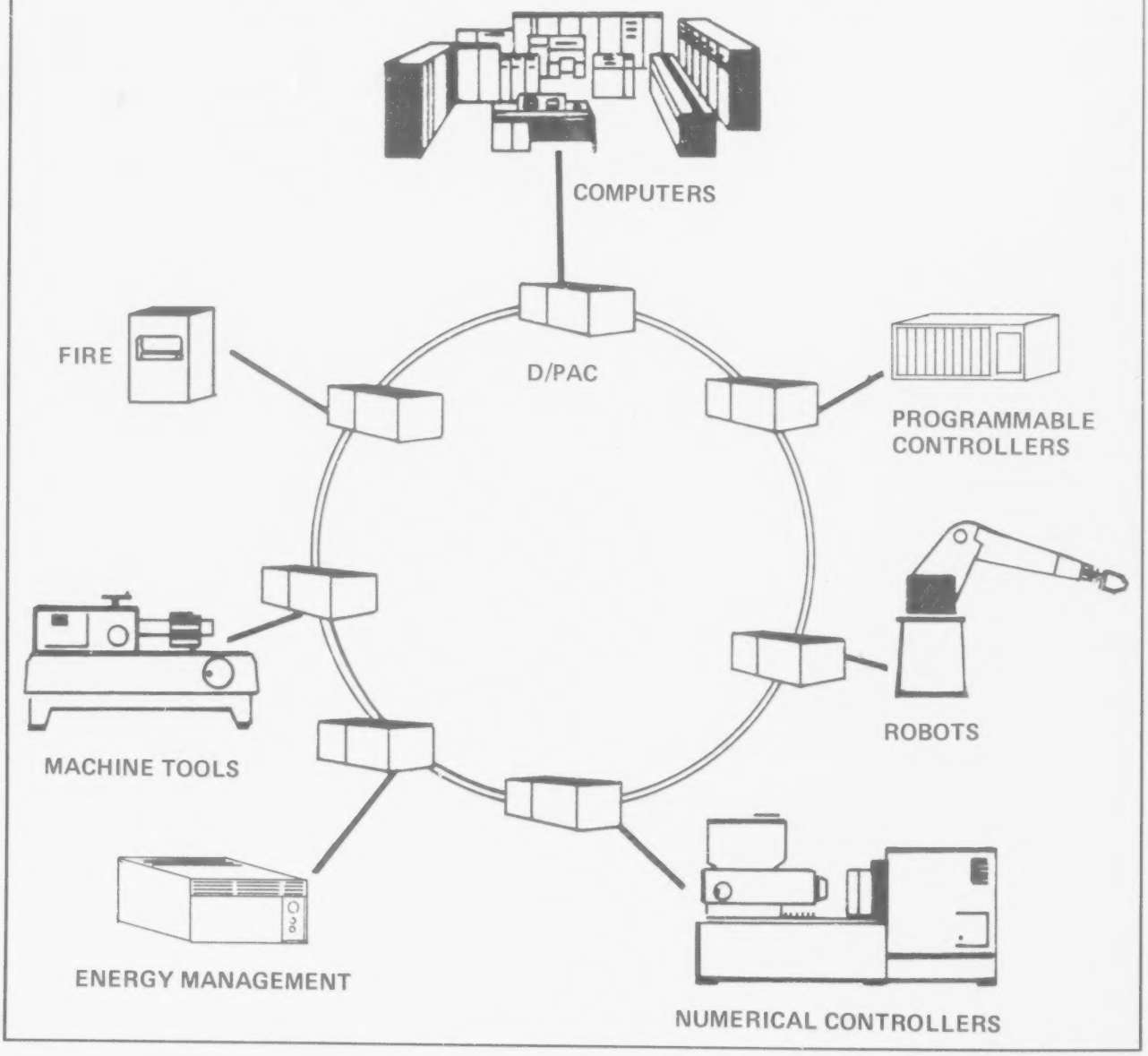
fully integrated control systems is without a doubt the objective most organizations are starting to pursue. Unfortunately, there are very few manufacturing facilities that function identically. Likewise, there are vast differences between alternative control strategies and systems. Consequently, selecting a control system for a specific operation, plant facility, or complex requires a solution unique to each situation.

In the wholly integrated manufacturing operation it is apparent that the key to automation lies in the choice of communications network technology. Most schemes for addressing these questions share some common features considered desirable for a network configuration. For one thing, most use a common transmission medium to allow each network node to communicate with every other network node (i.e., full connectivity). Today's highly automated manufacturing operations are likely to include machine tools, maintenance systems, programmable controllers and computers from many different vendors (domestic and international). Among these operations, there are likely to be several different protocols – that is, several different communications conventions.

FIGURE 1

INTEGRATED MONITORING AND CONTROL SYSTEM



Thus, the first job of a network system is to be able to communicate with every kind of distributed processor in the system.

Obviously, the question of which system configuration will provide the most cost-effective, reliable system is the one most often requested by manufacturing organizations. There are literally thousands of different configurations of hardware and software components that could accomplish the same job. Dependent upon the application, many factors become important in the selection of monitoring and control systems. For most users, the following parameters require consideration:

- Cost
- Maintainability
- Reliability
- Effective communication speed
- Noise immunity
- Multi-vendor protocol support and interfacing (i.e., PC, Robot, Host, etc.)
- Confidence of system operation through past applicable installations
- Graphics display of current data status

In addition, operators are concerned with the "friendliness of the system" and the ease of modifying or expanding operations or functions. Ease of modification can be accomplished only when the system is designed with that objective in mind.

Ideally, operators should be able to modify operations through hardware changes that are simple, quick, and easily communicated to the system. Likewise, when operator decisions are required, the system should display on the screen the "menu" of alternatives. With touch panels, the operator may respond simply by touching the screen. Diagnosing trouble spots may also be computer assisted. Such operator-friendly systems mean that jobs in the highly automated plant will not require advanced degrees, but, with more operator training, these jobs will be accessible to most members of the labor force.

Geometric Configuration

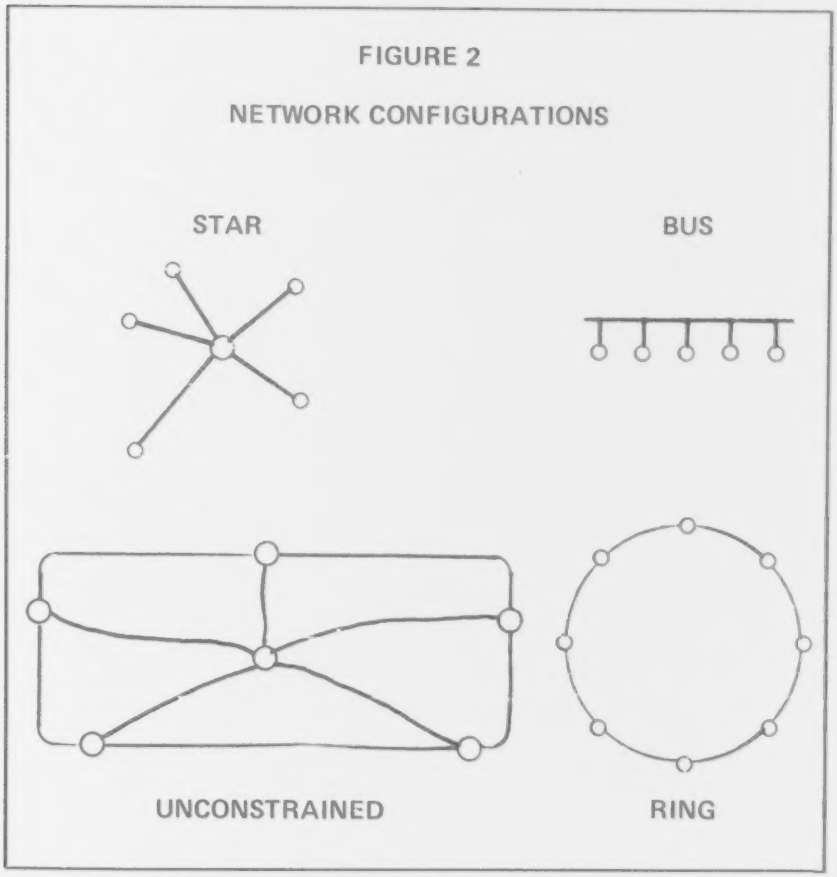
One fundamental difference in network schemes concerns the geometric configuration, or the way the system's nodes are linked together. Figure 2 illustrates four network configurations (bus, star, ring, and unconstrained) which account for the vast majority of today's systems. Their significance lies in their ability to operate a centralized or decentralized network. Both the unconstrained and the star are representative of centralized processing and usually involve large geographic distances, although they have been applied to manufacturing environments. A centralized system represents a relatively poor choice. When each of the distributed processors must send and receive its messages through a single central unit, the unit and its wiring must be large and complex. Even so, information may be held up in the queue before being processed, and data loss is more likely.

The bus and the ring, however, are characteristic of the decentralized network schemes appropriate for manufacturing environments. With decentralized control, the networks central unit acts primarily as a mailman, immediately routing information to the relevant distributed unit for decisions or processing. A network which is decentralized is also easier to expand and is more reliable, since its continued operation does not depend on any single element.

Other choices that must be made in designing a network include means for allocating access of the multiple nodes to the communications medium. At present, there are two basic approaches employed, with variations for each. Still other differences influence the technical and cost characteristics of network technology, including details associated with message packaging, routing, network interfacing, etc.

FIGURE 2

NETWORK CONFIGURATIONS



Clearly it is efficient communication that is the essence of network advantage, and the evolution of network technology has seen many advances to the medium used to support communications. Although there is an extensive range of options, most fall into a limited number of categories – twisted pairs, coax, and fiber optics. There are advantages and disadvantages to each.

Twisted pairs of copper wires are most familiar. They are among the lowest-speed and the lowest-density options. Unlike coax and optical fibers, a twisted pair can carry only one channel of information. In addition, twisted pair configurations are restricted to limited geographic areas. Their best performance is on small networks in relatively noise-free environments. Generally speaking, they are being replaced in most applications by more advanced media.

Coax Cable

An alternative which has been used in many network configurations is coax cable. Two versions exist – baseband and broadband. Both exhibit significantly better immunity to noise than twisted pairs. Further, since coax can carry multiple channels of information, allocating them either by time or by different transmission frequencies, the data rates are higher. Geographic areas are also increased. Each type, however, has significant drawbacks and is seldom cost-effective in a manufacturing environment. Simple acts such as adding a tap require retuning of the network. The system is inoperable during this period. Further, general maintenance needs can reasonably be expected to be higher than with other alternatives.

In the last several years, fiber optics have become a viable communications medium for the factory environment. These hair-thin glass fibers transmit information via light pulses at extremely high speeds. Fiber optics offer the highest data rates, the largest geographic distances, virtually absolute immunity from all types of noise, and many more advantages. These attributes make fiber optics well suited for utilization in manufacturing operations.

As efficient, fast, and cost saving as these network systems are, success nonetheless is directly related to a balance between the technical and human components. As systems become more sophisticated and automated, the role of the human operator becomes more critical. It is essential in the development of automated monitoring and control systems to take into account the interaction between the hardware involved and the human beings who are responsible for the day-to-day operation of the system. The ultimate goal in the design of a man/machine interface is to increase human motivation and efficiency, to integrate the operator effectively into the system, and thus, to increase productivity.

The focus then must be on the control console itself and the associated operator interfaces. Several of the parameters which turn out to be most important are the following:

- Communications speed
- Effective total system update rate
- Operator interfaces
- Menu-driven page design
- Resolution
- Cost

Many recent studies have shown that when an operator works with a color monitor, the colors and update speed of the screen contribute much to his performance. Operators tend to tire earlier, become bored faster, and have increased anxiety if the system operates too slowly.

The manner by which an operator interfaces to the system is also important. Some operators like keyboards; however, labor requirements are fewer when even this skill is not needed. The industry direction is toward the utilization of operators with little or no technical training, and operators simply interface through the use of screen touchpanels.

OPTONet

The state-of-the-art network system designed for Nissan, OPTONet, is a modular system of hardware and software building blocks developed specifically for operation in a manufacturing environment. It is a reliable network for high-speed data gathering, processing, transmitting, and feedback control. From a hardware viewpoint, it is equivalent to a full-scale minicomputer. It consists of modular nodes of variable size which provide both network communications, and interfacing, as well as distributed processing. It can utilize black and white and/or color monitoring, with screen touchpanels for operator interface, all linked together with a fiber optic communications medium that has redundant, or back-up, capacity.

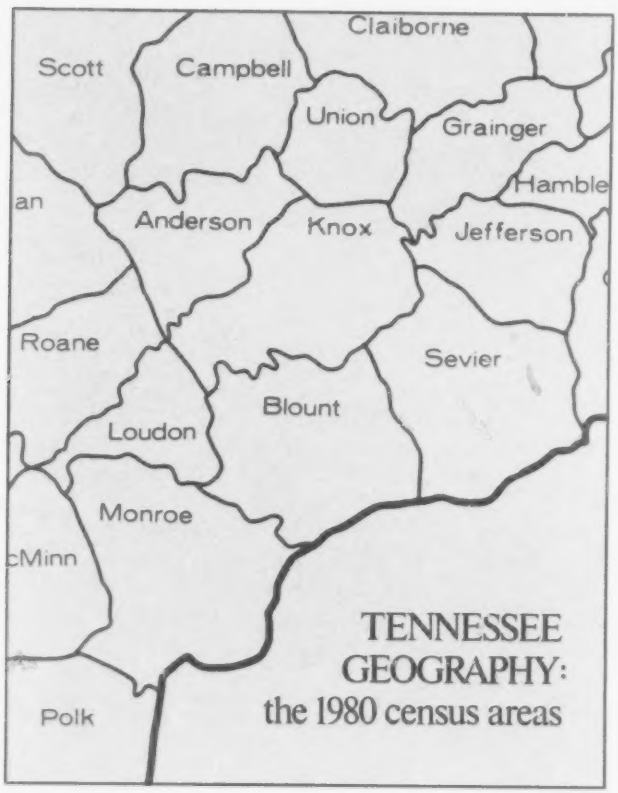
The software has three different logical aspects: an operating system, data base management, and various application modules. It is structured to permit the easy implementation of changes or enhancements to the network configuration. Operators interact through fail-safe menu selections, and the system provides extensive self-diagnostics at all levels.

Conclusions

There is a myriad of system and hardware vendors than can address these considerations, in one form or another. All involve selections from three basic parts of the system – the communications media, the network interface/intelligence, the operator interface, and finally, their subsequent integration. These systems can be employed in some form whether the plant is to be built from the ground up, as is the Nissan truck facility, or whether it has been in production for years. For older plants it may, in fact, be essential to make use of such integrated control systems to remain competitive, but when the system is to be designed, it should be undertaken only by knowledgeable, experienced staff, or outside consultants, using care for each new application.

The management trend toward plantwide, integrated, distributed control systems and their technological advantages can be the strategic factors in helping American industry retain its edge in international competition. ■

GEOGRAPHY REFERENCE BOOK NOW AVAILABLE



The Tennessee State Data Center has published a reference book that may be just what you need to get your Census data all sorted out. Entitled **Tennessee Geography: The 1980 Census Areas,** the book's primary purpose is to explain the concepts of census geography. Details from Tennessee census maps supplement the discussion, and county examples serve to illustrate the differences between metropolitan and nonmetropolitan geography. A glossary of geographic terms not only defines the various geographic concepts, but indicates their historical comparability.

In addition, the book should help you find data for your specific area. The final section lists each county and place in Tennessee, its 1980 population, and the number and type of its geographic subdivisions. For example, referring to Bledsoe County, we find that it has 3 census county divisions, 8 enumeration districts, and a population of 9,478. Its only place, Pikeville, is blocked; it has 3 block groups and 1 block numbering area. Knox County has 9 census county divisions, 5 census-designated places, and 1 incorporated place. All are blocked, and there are 79 tracts in the county. The data locator table tells you in which printed reports, summary tape files, or microfiche you can expect to find data for each kind of area.

Data users who wish to have the geography reference book can order it at a cost of $4.00 from the Center for Business and Economic Research, Suite 100 Glocker Business Administration Building, The University of Tennessee, Knoxville, TN 37996-4170. The price includes shipping and handling and can be prepaid or billed.

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